PREFACE

The preparation of this work was suggested by the inability of the author to refer beginners in systematic botany to literature treating of descriptive taxonomy from the standpoint of technique. De Candolle's " La Phytographie," published in 1880, is the only book devoted to the subject and that, naturally, is out of date, many problems having developed since it was written. Descriptive taxonomy at present may be likened to a craft, in which the art or technique has not been committed to writing but is handed down by tradition.

During the past thirty or forty years, taxonomic botany has developed working methods differing from those of most early systematists in the greater amount of field work done and in the greater precision in nomenclature. The period of the author's own taxonomic work coincides with that of this recent development. In his opinion, the beginners in taxonomy today, as well as somewhat more advanced students, might well profit by the time that has been spent and the pains that have been taken to further this development, as well as by the mistakes that have been made. It is for this reason that the author has set down what some twenty-five years of taxonomic work has taught him of the art and science of his craft. The first six chapters deal with the elements of descriptive taxonomy; the remainder of the work treats of the subject from the standpoint of advanced students or those beginning their professional careers as assistants in botanical institutions.

Along with the strictly taxonomic development of the subject, there have been included chapters or paragraphs dealing with more or less related subjects which it was thought might be helpful.

When treating of taxonomic methods the author has, in many cases, given suggestions along rather definite lines but has tried to make it plain that a method which he personally prefers is not necessarily the only method, or a better one than that followed by others. In giving examples he hopes he may be pardoned for choosing in so many cases those presented by the grasses, as naturally they are more familiar to him.

A. S. HITCHCOCK.

June, 1924.

CONTENTS

DESCRIPTIVE SYSTEMATIC BOTANY

CHAPTER I

INTRODUCTION

Taxonomy is the science of classification, more especially as applied in biology. In the present work the subject is considered in its relation to plants, but the general principles apply equally well to animals.

Relation of Taxonomy to Other Branches of Botany

Taxonomy is fundamental in that it is the basis for coordinating the work in all branches of botany, which involve the identity of species. It is evident that the results of work in morphology, physiology, or other lines are comparable only if the identity of the species investigated has been determined with certainty. The discrepancy in the conclusions reached by two botanists investigating, at different times, supposedly the same species may be explained when it is shown that the material represented two distinct species. Every worker should first of all determine definitely the identity of the species he is investigating and should preserve the material in order that its identity may be confirmed.

The morphologist or physiologist is usually not a trained taxonomist and must rely on the taxonomist for his determinations. He should exercise care and not accept names upon labels, either in herbaria or gardens, unless these names have been confirmed by competent taxonomists.

The conclusions reached by the plant geographer on the distribution of species and the origin and relation of floras, and by the ecologist on phytogeographic areas, depend for their reliability on the accurate identification of the species

concerned. For example, a recent flora of the Galapagos Islands lists *Cenchrus distichophyllus*, a species known only from Cuba. The specimen proves to be *Sporobolus virginicus*, a widely distributed tropical strand-grass. Such an error would seriously mislead an ecologist.

An important function of the professional taxonomist is that of identifying specimens submitted by workers in other branches. The seedsman submits seeds obtained from foreign sources, in order that he may definitely announce the species he distributes and that he may know the character of the impurities present. The horticulturist and agriculturist receive plants from abroad under various names, and wish to know whether the names are correct. The taxonomist is asked to answer this question, in which large sums of money may be involved. The mycologist wishes to know the host of the parasitic fungus he is studying; the entomologist, the hosts of injurious insects; the physician, the kind of germ causing disease; the water-supply engineer, the species of algae contaminating reservoirs; the ornithologist, the origin of seeds found in stomachs of birds. In all lines of botanical work the identity of species is a fundamental consideration. It is the function of the taxonomist to determine or confirm such identification.

The Scientific Attitude

Taxonomic botany, in comparison with other branches of the subject, calls for an unusual amount of judgment in weighing and interpreting facts. Research in taxonomic botany is the product of constructive thinking applied to facts ascertained by observation or experiment. Much of the success in original research depends upon the possession of what is frequently called the scientific attitude. It may be worth while, then, to consider briefly this aspect of our subject.

Scientific investigation is fundamentally a search for truth. It seeks to establish facts. At the outset one must distinguish between that which is a fact and that which is

supposed to be a fact. One must divest oneself of all biased opinions, all preconceived theories or notions. In other words, one must approach one's subject, one's search for truth, with an open or unprejudiced mind. This mental condition is called the scientific attitude.

Not only should the student approach his subject with an open mind but he should maintain the scientific attitude throughout his investigation. He must guard against being influenced unduly by his own conclusions, that is, he must learn to abandon his own conclusions unreservedly if additional facts show them to be untenable.

This condition of open-mindedness is not natural with most of us but is the result of mental discipline. The average person is influenced by tradition and swayed by prejudice. The race has not yet outgrown the hampering effects of its savage ancestry; the mental attitude of our childhood days persists in our maturer years; and the average social environment retards rather than hastens the development of independent thinking. A mind permitted from infancy to develop originality and independence, taught to think clearly, and protected meanwhile from modifying influences of environment, would be the ideal one for scientific investigation, but such minds are so rare that they are practically non-existent. The conventional training received by a child at home and at school teaches him to think as others think, and to accept established customs without question. Social environment hinders the development of the scientific attitude because even the most enlightened peoples tend to accept things as they are and to resist changes in established customs. The average individual does not think independently on social, moral, or political questions but accepts, often unconsciously and usually without much question, the opinions of the mass. Even scientists, when considering such questions, may abandon their scientific attitude.

One of the most important functions of a scientific education is to teach the student to think clearly and independ-

ently. It may be assumed that he has already developed this ability before he undertakes the study of systematic botany, but so persistent is the effect of early training that one may be excused for suggesting constant vigilance.

In systematic botany the facts are largely established by repeated observations, and statements concerning the relationships and limits of groups are in part the expressions of intelligent judgment based upon these observations. The judgment approaches the truth in proportion as it is the result of accurate observation, clear thinking, and the unbiased weighing of evidence. Having reached a conclusion, the student should not hesitate to change it in the light of new evidence. Above all, he should avoid the temptation to defend his opinion, especially his published opinion, simply because it is his own. It is not uncommon for one who has retained his scientific attitude during the progress of a piece of research to change this attitude for one of determined adherence to his own conclusions, when these have been published, even though new and modifying facts have been brought to his notice. So unconsciously does prejudice insinuate itself into his mental attitude that the student must be constantly on his guard. Not only should he at intervals check up his conclusions, but he should also examine his own mental machinery to see that it is working in the proper manner.

The Basis of Modern Classification

Identification presupposes a classification. Organisms may be and have been classified in many ways, according to their general form and structure, that is, as trees, shrubs and herbs, or according to the color of the flower or the shape of the leaf; but the generally accepted classification in use at the present time is based upon genetic relationships. The theory of organic evolution assumes that the organisms of today are descended from similar though slightly different organisms of the past and that all organisms are genetically related.

We need not concern ourselves in the present discussion with the origin of life nor with the question whether all life arose from a single source or from multiple sources. It is generally accepted that organisms vary from generation to generation, that characters are transmitted from parent to offspring, and that the lines of descent diverge. A study of inheritance and variation, together with common observation of domestic animals and plants, has shown that certain characters, called fundamental or inherent, are inherited with certainty; other characters, called superficial, are easily modified, are subject to variation, and are inherited in a less certain or less definite manner. The investigation of the laws of inheritance belongs to the study of genetics.

The organisms of the present represent a cross section of the lines of descent. A study of the laws of variation and inheritance — genetics — and a study of the fossil remains of the organisms of the past — paleontology — lead us to assume that divergence in fundamental characters of organisms took place in the remote past. For example, fishes, reptiles, birds and mammals, became distinct groups of vertebrates at a very early period; at a later period such groups as the horse family and the cat family arose; at a comparatively recent period the species of the cat group, the dog group, and the horse group became distinct; while the varieties of domestic animals probably came into existence during historic times or during the era immediately preceding.

The modern classification of animals and plants is an attempt to arrange the groups of individuals in a system which shall represent their genetic relationships. It is clear that such a system can be only an approximation to the truth, depending on our knowledge. As our knowledge increases, the system is changed to correspond.

Organisms may be studied from many standpoints, such as those of anatomy, physiology, morphology. Taxonomy may glean facts from various domains, but it is chiefly from

morphology that the facts that indicate probable relationships are gained.

Since it is the purpose of this book to outline the principles of botanical classification, and more particularly the elementary principles of the technique, it will be well to draw a distinction between classification itself and the study of the facts which form the basis of classification. The study of the structure of plants for the purpose of comparison is usually called comparative morphology. The study of the internal or microscopic structure of plants is called plant anatomy and when correlated with the study of function, that is, when it becomes a study of organs, is often called internal morphology. The study of external organs or forms has been called external or gross morphology. The relations of the larger groups of plants, such as orders and higher divisions, are shown chiefly by a study of the fundamental organs and are revealed usually through investigations in internal morphology. The relations of species, and even of genera, are shown chiefly through comparisons of external organs.

That portion of taxonomy which deals with the descriptions of species, and their arrangement in groups, may be called descriptive taxonomy. Manuals, floras, descriptive monographs or revisions of groups, and all the technique belonging thereto, are included in the domain of descriptive taxonomy.

In the classification of species we are concerned mainly with the differences of organisms. In the classification of the orders and higher groups we are concerned mainly with the resemblances of organisms. In the classification of genera and families we must balance differences and resemblances.

In the present work it is proposed to take up the elementary technique of descriptive taxonomy. For the general student this book may serve as an interpretation of modern methods. For the student who plans to delve deeper into the study and to do original work in what is usually called systematic or taxonomic botany, it may serve as an elementary guide.

CHAPTER II

CATEGORIES USED IN THE NATURAL SYSTEM

Classification serves the double purpose of showing relationships and of aiding in identification. From the practical standpoint of descriptive taxonomy, classification is primarily a matter of convenience in so far as it aids in the identification of groups. The number of the species of plants is so large that some method of orderly arrangement becomes necessary as a basis for any kind of an investigation concerning them. This need was recognized early in botanical history. The first attempts at classification were based upon such differences as those of use or habit. The history of classification is an interesting subject in itself but can not here be developed. Linnaeus devised a system based upon the number and position of the stamens and pistils. This system, known as the sexual or Linnaean system, was a great advance over the systems previously in use, as it rendered much easier the identification of species. All these systems were artificial ones, as they did not arrange plants according to their natural affinities. Linnaeus himself declared that the ultimate system of classification would be a natural one which would show affinities. A natural system, which was proposed later and which has been developed as our knowledge has increased, is the one now in general use.

Species

The earth abounds with individual plants. Every individual is the offspring of a parent (in nearly all cases among the higher plants, of two parents) and is a given point in an indefinite line of descent. The innumerable lines of descent reach back into the remote past, and at every stage

each line may merge with other lines. According to our present theory of development, there has been a gradual change in the species through variation of the individuals, but all are genetically related through the branching lines of descent. This means that all the individuals of a family of plants would be found to be related to one another if the genealogy were traced far enough into the past. What may once have been a homogeneous group has now become hundreds of differentiated groups.

The unit of classification is a coherent group of like individuals, called a species. The term is difficult to define with precision because a species is not a definite entity but a taxonomic concept. Where the line shall be drawn is often a matter of convenience in classification. Diagrammatically, we may consider the present as a cross section of the lines of descent from the past, each individual being represented by a dot. If the lines of descent are arranged according to the degree of resemblances the dots will be arranged in groups on a plane. We may now outline the groups of dots and call them species. Certain groups are definitely separated from the others, and form distinct or well-marked species. Other groups are connected by scattered dots. In some cases, there is a definite group of dots which shows a strong tendency to be segregated into two minor groups connected by numerous scattered dots. Botanists will differ as to whether we have here two species with intermediate individuals, one species with two varieties or subspecies, or one variable species. In practice we are handicapped by lack of knowledge. We usually know only a relatively small number of individuals of a species and must draw our conclusions from these. It may readily be seen that the actual delimitation of a species is a matter of judgment and experience. The various races and tribes of men are usually recognized as belonging to a single species. With many this example forms a basis for the concept of a species. The unit of classification, as stated above, is the species. The species are grouped into genera, the genera

into families, the families into orders, and the orders into higher groups.

Genera

Genera are groups of related species. By general consent and common observation, mankind has long recognized certain groups of related species, such as the oaks, the pines, the grapes and the goldenrods. Such groups form the basis of the botanist's concept of a genus. But we find differences of opinion among botanists as to whether the plums should be grouped with the cherries, the apples with the pears, the blackberries with the raspberries, the spruces with the firs, or whether the two members of each of these pairs should be recognized as distinct genera. The tendency now is to recognize distinguishable groups of species, like the above-mentioned, as distinct genera; but, after all, it is largely a question of the personal judgment of the classifier, modified by custom.

There are many cases where a single species has no near allies and forms a genus by itself. On the other hand, there are genera, such as *Carex* and *Senecio*, that include hundreds of closely allied species.

Most botanists attempt to be consistent in delimiting the genera of a single family, basing the concept on essentially the same degree of differences in the several cases.

Convenience may play a rôle in determining generic lines. Extremely large groups may be broken up on the basis of differences of smaller degree, if common to a group of closely allied species, than if the group consisted of a few species.

In general, the botanist, in delimiting genera, keeps in mind two important requirements, that of showing natural affinities, and that of aiding correct identification.

Families

Families are groups of related genera. There are several groups of this kind which have been long recognized and

which are known as natural families. They consist of genera in which the relationships are obvious. Such families, for example, are the grasses (Gramineae or Poaceae), the sedges (Cyperaceae), the crucifers or mustard family (Cruciferae or Brassicaceae), the umbellifers or parsley family (Umbelliferae or Apiaceae), and the composites or sunflower family (Compositae or Asteraceae). Because of our lack of knowledge, the grouping of many genera is as yet only tentative, and many families consist of genera the affinities of which are doubtful.

Higher Groups

As it is not the purpose of this book to deal with the comparative morphology of the higher groups of plants, we need only mention here that related families are grouped into orders. The grasses and sedges form an order; the lilies, rushes, irises, amaryllises, and a few allied families form the Liliales or lily order; the morning-glories, borages, verbenas, mints, figworts, and allied families form the order Polemoniales. The orders are the highest aggregates of which a given group is a type. The orders are aggregated into successively higher groups on the basis of a few fundamental morphological characters common to the members of each category. The more prominent subdivisions of the Vegetable Kingdom, given in reverse order, are shown below. The two great branches are the cryptogams (Cryptogamia) consisting of fungi, algae, hepatics, mosses and ferns, all of which are plants without true seeds; and the phanerogams, spermatophytes, or seed plants (Phanerogamia or Spermatophyta), which are plants with seeds. The seed plants are again divided into the Gymnospermae (cone-bearing plants and their allies), and the Angiospermae, the ordinary flowering plants. The Angiospermae are divided into two great classes, the Monocotyledoneae and the Dicotyledoneae. The latter class is again divided into Archichlamydeae, or Choripetalae (corolla absent or of separate petals) and Metachlamydeae, or Gamopetalae

(corolla of united petals); but the distinction here is often rather arbitrary and may separate allied orders.

Subdivisions of the Species

From what has been said of the species it is clear that in many cases the individuals tend to group themselves according to minor characters. Representative individuals may be sufficiently different to be assigned to distinct species. But an examination of a large number of individuals may show intergrades which connect the groups so that no sharp line can be drawn between them. It is sometimes convenient to give names to these more or less distinct groups within the species.

The primary subdivisions are usually known as varieties or as subspecies. Some authors carry the classification of the species further, and, in very polymorphous groups, recognize several categories. They may have subspecies, varieties, subvarieties, forms and subforms. Cultivated plants are susceptible of a high degree of classification in this respect.

The tendency, especially among most American botanists, is to recognize among wild plants only one subdivision of the species. It is evident that the subdivisions may have very unequal rank, and this inequality may be indicated by several categories of minor groups; but from the standpoint of convenience in the use of the terms and in the designation of groups, the method of having a single category below the species is preferable. In naming the subdivisions of species two concepts are recognized.

According to the first concept, the varieties are appended to the species. There is, then, the typical or original form, the form which was first recognized and described, which is known as the species. The variations are appended to this species as varieties (or subspecies).

Example. In Gray's Manual, *Carex stricta* is described as a definite group. To this are appended three varieties, *curtissima*, *angustata* and *decora*.

According to the second concept, a species is considered to be a group of varieties, and the varieties stand in the same relation to the species as the species to a genus. The typical form is given a varietal name, usually such as *genuinus*, *typicus*, or the specific name with the prefix *eu-*. This method is more common in Europe.

Example. The example cited above might become *Carex stricta*, with four varieties of which the first might be var. *genuina* (or *typica*, or *eu-stricta*).

CHAPTER III

NOMENCLATURE

The botanical names of plants are composed of Latin words. Each species is distinguished from all others by its name, which consists of two parts, the generic and the specific, the first indicating the genus to which the species belongs and the second distinguishing the species of that genus. Precision in distinguishing species by name requires that no two valid genera shall bear the same name, and that no two valid species in one genus shall bear the same name, though the same specific name may be used in different genera.

Example. The Latin name of the oak genus is *Quercus;* the white oak is *Quercus alba.* The poplars belong to the genus *Populus;* the white poplar is *Populus alba.* There can be but one valid genus *Quercus* or *Populus,* and only one valid species named *alba* in each genus.

The Generic Name

The name of the genus is a noun in the singular and is always written with a capital letter. The noun may be derived from a language other than Latin, but in this case it is Latinized in form or is treated as a Latin word.

The generic name usually indicates some character prominent in its included species, or it may be given in honor of a person. Sometimes it indicates the aboriginal name of the plant; sometimes it is an anagram or some other meaningless combination of letters. Many of the genera of the earlier authors bear the original Latin or Greek names by which the plants were commonly known before the days of technical nomenclature.

Example. Quercus, Betula, Alnus and *Fagus* are the ancient Latin names for the oaks, the birches, the alders and the beeches. *Phyllanthus* is from the Greek *phyllon,* leaf, and *anthos,* flower, because in some species

the flowers are borne along the margins of flat leaf-like branches. *Zanthoxylum* is from the Greek *zanthos* (or *xanthos*), yellow, and *xylon*, wood, because of the color of the wood. *Liquidambar* is from the Latin *liquidus* and the Arabic *ambar*, amber. Such a name as the last, derived from two languages, is not formed according to the best usage. *Jeffersonia* was named in honor of Thomas Jefferson. *Anogra* is an anagram of Onagra. *Crotonopsis* is from *Croton* and the Greek *opsis*, like or near, from its resemblance to the genus *Croton*. *Cornucopiae* (*Cornu copiae*, horn of plenty) is a rare case of a generic name formed from two separate Latin words, the genitive ending, *ae*, giving the word the aspect of a plural.

The Specific Name

The specific name may be (1) an adjective, (2) a noun in apposition, or (3) a noun in the genitive case.

1. An Adjective. — The word then agrees in gender with the generic name. When the specific name is an adjective it usually indicates some distinguishing character, or at least a character present in the species. Sometimes it indicates a locality or a person.

Examples. *Rosa alba* would be a white rose; *Rosa gallica*, a French rose; *Rosa virginiana*, a Virginia rose; *Carex Deweyana*, Dewey's *Carex*.

Note on Latin Grammar. — Since the study of taxonomic botany is not always preceded by the study of Latin, attention will here be called to the few rules necessary for a proper understanding of generic and specific names.

The generic name is always in the singular number and in the nominative case. In Latin there are three genders, masculine, feminine and neuter. The following examples will show the forms assumed by some common adjectives to indicate gender.

Masculine	*Feminine*	*Neuter*	*English Equivalent*
albus	alba	album	white
niger	nigra	nigrum	black
tener	tenera	tenerum	delicate
viridis	viridis	viride	green
acer	acris	acre	sharp
repens	repens	repens	creeping
velox	velox	velox	swift
altior	altior	altius	higher
bromoides	bromoides	bromoides	brome-like

The gender of the generic names can be determined from a Latin lexicon if they are classical words. Many generic names, however, have been coined in recent times and will not be found in lexicons. The rules governing the gender of nouns are too complex to be of value to those who have not studied Latin. The student can determine the gender of generic names used in manuals by noting the form of the adjective specific names. By noting the genus *Carex* one will see that adjectives of the form of albus, when used with the generic name *Carex*, end in *a*, indicating that the generic name is feminine; similar specific names in *Andropogon* end in *us*, and in *Panicum* end in *um*, indicating that these genera are masculine and neuter respectively.

Nouns ending in *a* are usually feminine, and those ending in *um* are neuter. Nouns ending in *us* are usually masculine, except the names of trees, which are feminine (e.g., *Quercus*, *Populus*, *Fagus*, *Pyrus*).

A genus named in honor of a person is formed by adding *a* or *ia* to the name of the person, and is feminine (e.g., *Bartonia* for Professor Barton, *Torreya* for Doctor Torrey).

When a species is transferred from one genus to another, the termination changes, if necessary, to accord with the gender of the new generic name (e.g., *Panicum italicum* when transferred to *Setaria* becomes *Setaria italica*).

2. A Noun in Apposition. — A noun used thus is in the same case as the noun with which it is in apposition. As a generic name occurring in English discourse is always in the nominative case, this is also the case of the specific name when the latter is a noun in apposition. Such a specific name does not necessarily agree in gender with the generic name.

Examples. *Pyrus Malus*, the apple; *Prunus Cerasus*, the sour cherry; *Allium Cepa*, the onion.

3. A Noun in the Genitive Case. — This is a common form when a species is named for a person. Such names are formed by adding *i* or *ii* to the name of the person (or

ae if named for a woman). Such a name does not necessarily agree in gender with the generic name.

Examples. *Carex Davisii*, the equivalent of the carex of Davis; *Carex Fraseri* (whether *i* or *ii* is added is a matter of euphony); *Carex Jonesae.*

Occasionally the specific name is a common noun in the genitive plural.

Examples. *Polygonum dumetorum* (of the thickets); *Convolvulus sepium* (of the hedges).

Varietal or Subspecific Names

The varietal name follows the same rules as the specific name. If an adjective, it agrees with the generic name; if a noun in apposition or in the genitive, it does not necessarily agree.

There are two general methods of indicating the variety or subspecies.

The first method is to interpolate the word variety (*varietas*) or subspecies, usually abbreviated, between the specific and varietal names.

Example. *Carex stricta* var. *curtissima.* In older works the subdivisions are often indicated by Greek letters. *Carex stricta* β *curtissima* (alpha being reserved for the typical form); *Carex stricta* γ *angustata;* and *Carex stricta* δ *decora.*

The second method is to place the varietal name immediately after the specific name, the whole forming a trinomial.

Example. *Carex stricta curtissima.*

Names of Groups Superior to the Genus

As stated previously, genera are grouped into families, families into orders, and orders into various higher groups. In practice the important category above the genus is the family. In large families it may be convenient to interpolate subfamilies and more especially tribes.

The names of the families and of the tribes are made by adding to the stem of an important included genus the termination -aceae or -eae, respectively.

Examples. *Rosaceae*, the rose family, from *Rosa*, the rose genus; *Ranunculaceae* from *Ranunculus;* *Cyperaceae* from *Cyperus;* *Roseae*, the rose tribe; *Agrostideae*, the Agrostis tribe.

A few families have special names which have the sanction of custom, but there is a tendency to replace these by names regularly formed. These families are: Gramineae, the grass family (or Poaceae); Cruciferae, the mustard family (or Brassicaceae); Leguminosae, the legume or pulse family (or Fabaceae); Umbelliferae, the parsley family (or Apiaceae); Labiatae, the mint family (or Menthaceae); Compositae, the composite family (or Asteraceae).

Changes in the Names of Plants

It is confusing to the beginner to find that different names are applied to the same plant by different people or in different books. The technical details concerning nomenclatural changes are taken up in subsequent chapters, but a few of the more common reasons for the use of different names will be explained here.

The existence of different names for the same plant may be due either to the fact that more than one name has been applied to the same species, or to a mistake in the identity of a species. Different names applied to the same plant are called synonyms. Synonyms may arise independently, as where two persons describe a species under different names; or they may be due to differences in opinion as to the genus to which a species belongs. The peach is called *Prunus persica* by some and *Amygdalus persica* by others, because some place the peach in the same genus as the plum and others keep the peaches in a separate genus, *Amygdalus*. In like manner there may be different opinions as to the forms of a variable species. For example, the species of *Crataegus* as described in Gray's Manual are difficult to distinguish. Some botanists would include under *Crataegus crusgalli* all the species of the group (species 2–6). Others would distinguish still more species, recognizing as valid the ones that now appear as synonyms in the text (*C. Palmeri*

and *C. grandis* under *C. pratensis; C. Pennypackeri* under *C. Canbyi*). These differences depend upon the judgment or opinion of different botanists.

Changes of names in successive editions of the same work may be due to the correction of errors. *Panicum scoparium* of the sixth edition of Gray's Manual is changed to *P. Scribnerianum* in the seventh edition, because in the former the name was applied to the wrong plant.

CHAPTER IV

AUTHORS OF TAXONOMIC GROUPS

The person who first properly publishes (see Chapter V) the name of a genus, species, or other taxonomic group is said to be the author of that group, and in formal citations the author's name, usually abbreviated, is placed after the name of the group.

Examples. *Geum* L. Linnaeus first published the name *Geum* for a genus of plants. *Geum strictum* Ait. Aiton first published the name *Geum strictum* for a species of the genus *Geum*.

Abbreviations of Authors' Names

For convenience, the names of well-known authors are abbreviated. There is no definite standard or rule for the abbreviation of a name, but it is generally understood that the abbreviation should not be ambiguous. The names of obscure or little-known authors are not usually abbreviated. In general, the abbreviation retains the letters of the author's name in sequence up to the part omitted. The better known the author the more his name can be abbreviated. Certain names are so familiar that they allow of extreme abbreviation, as L. for Linnaeus, DC. for De Candolle, H.B.K. for Humboldt, Bonpland and Kunth. On the other hand, Robinson, though well-known, is not usually abbreviated because of the danger of confusion with other names, such as Roberts, Robin, Robins and Robertson. Different persons with the same name require initials or some other designation. W. J. Hooker and his son, J. D. Hooker, are usually distinguished by abbreviating the first as Hook. and the second as Hook. f. (filius). The elder De Candolle is abbreviated DC., the son, Alphonse, A. DC., and the grandson, Casimir, C. DC. The American Asa

Gray is distinguished from the English S. F. Gray by giving his initial.

In some older works one may find abbreviations, such as W. for Willdenow, F. for Fries, or Lmk. for Lamarck, that are not intelligible except to those familiar with the region or the group of plants concerned. The common practice now is to preserve in the abbreviation enough of the word to identify the name in a catalog of literature. The letters T. & G. would be admissible for Torrey and Gray though the individual letters would not be sufficient for these authors separately.

The following are a few of the rules governing the abbreviation of authors' names appearing in the Contributions from the National Herbarium.

1. Names of one syllable are not abbreviated.
2. Names of more than one syllable, when abbreviated, should always stop before a vowel and should go at least to the vowel of the second syllable.
3. The following names of authors are specially abbreviated: L., DC., B.S.P., H.B.K., Michx., R. Br.
4. To distinguish different authors of the same name, initials may be used; or in case of father and son, the name of the latter, or its abbreviation, may be followed by f. (filius).
5. Names that, to avoid confusion, are not abbreviated when standing alone, may be abbreviated when combined with another (Britton; Britt. & Rose).

The following list of names and their abbreviations is representative:

Bentham	Benth.
Braun, Alexander	A. Br.
Brown, Robert	R. Br.
De Candolle	DC.
Engelmann	Engelm.
Humboldt, Bonpland and Kunth	H.B.K. or HBK.
Lamarck	Lam.
Linnaeus	L. or Linn.

Marshall	Marsh.
Meyer, C. A.	C. A. Mey. — there are several Meyers.
Michaux	Michx., or less desirably Mx.
Muhlenberg	Muhl.
Nuttall	Nutt.
Poiret	Poir.
Pursh	Preferably not abbreviated.
Roemer and Schultes	Roem. & Schult. or R. & S.
Swartz	Unabbreviated, or Sw.
Torrey	Torr.
Willdenow	Willd.

Use of the Parenthesis

When a species, originally described in one genus, is later transferred to another genus, the name of the author of the original specific name (if the parenthesis system is used) is placed in a parenthesis, and this is followed by the name of the author who has placed the species in the accepted genus.

Example. *Agrostis indica*, first described by Linnaeus, was later placed in the genus *Sporobolus* by Robert Brown. The name is therefore written *Sporobolus indicus* (L.) R. Br.

This is a relatively recent innovation and is not yet commonly used except in America. The object is to show that the species was first described under a different genus. Sometimes it happens that the original author of the species transfers it later to another genus. In this case the name within the parenthesis is the same as that after it. However, botanists are not in accord as to the practice in this particular case, and usually the parenthesis is omitted.

When an author transfers a species from one genus to another he is said to make a new combination. At the time of publication he may place his own name after the new combination or, if the authorship is clear from the context, he may omit his name.

It is often the practice among zoölogists and occasionally among botanists to cite only the original author of the

species in parenthesis and omit the author of new combinations.

Example. *Agrostis indica* L.; *Sporobolus indicus* (L.).

The parenthesis system is applied also to varieties and subspecies, and to genera and their subdivisions.

Examples. *Nyssa biflora* Walt. is made a variety of *N. sylvatica* by Sargent, and the name is written *N. sylvatica biflora* (Walt.) Sarg. The genus *Amygdalus* L. is considered by some botanists to be a section of *Prunus* and would be written by them *Prunus* sect. *Amygdalus* (L.) Benth. & Hook.

A particular application of this system is made in the case of generic names that were in use before the publication of Linnaeus' " Species Plantarum " in 1753, the date of the beginning of binomial nomenclature (see page 152). If a generic name used by Linnaeus or his successors was employed in a formal manner by an earlier author (in the same sense), the first author's name is, by some botanists, placed in parenthesis or in square brackets. Such generic names are said to be adopted from pre-Linneaen authors.

Example. The genus *Prunus* was first formally described by Tournefort (1700) and was taken up by Linnaeus. It may be written *Prunus* [Tourn.] L.

CHAPTER V

THE USE OF MANUALS AND FLORAS

The work of the taxonomist, after having passed the student stage, may be routine or constructive. By routine work is meant, broadly, the identification of plants. By constructive work is meant original work, such as the making of floras or the revision of groups. Work with the known must precede work with the unknown in taxonomy, as in all lines of human endeavor. A large part of the time of a professional taxonomist is occupied in the identification of plants. The more expert he becomes the more he is called upon by colleagues and laymen to give the benefit of his knowledge. In the limited field of agrostology, the office of the agrostologist is called upon each year to identify from six thousand to eight thousand specimens of grasses. It is chiefly through this routine work that taxonomy supports and benefits other branches of botany. It is the training the systematist receives while thus working in relatively known ground that enables him to strike out into the unknown, to do original work, and to publish the results.

The first serious contact of the student of botany with the taxonomic branch of the subject is usually the result of an effort to identify the native plants of his locality. To learn the names of the plants he must use a flora of the region, if there be one.

A descriptive flora, or manual, is an orderly arrangement of species with descriptions, often supplemented by keys and sometimes by illustrations, with the aid of which the student may determine the names of the native plants of a limited region. In this work the flowering plants only are being considered, but the principles stated are applicable also to the lower groups. Descriptive floras fall into two

groups, manuals and local floras. A manual is a work covering a country or a large section of a country. A local flora covers a more limited area, such as the vicinity of a city, a county, a valley, or even so great an area as a state. There is no completed flora of North America, of the United States, or even of Europe, which is better known, botanically, than any other area of its size. There are six modern manuals covering areas within the United States. These are:

ROBINSON AND FERNALD. Gray's New Manual of Botany, covering the area from Missouri east and north.

BRITTON. Manual of the Flora of the Northern States and Canada. Western boundary of Kansas, east and north.

BRITTON AND BROWN. An illustrated Flora of the Northern United States, Canada and the British Possessions, 102d meridian east and southern boundary of Virginia north.

COULTER AND NELSON. New Manual of Botany of the Central Rocky Mountains. Northern New Mexico to southern Idaho.

RYDBERG. Flora of the Rocky Mountains and Adjacent Plains. Colorado to Alberta.

SMALL. Flora of the Southeastern United States. North Carolina south, west to 100th meridian.

A manual consists of the following parts: a key to the families; descriptions of the families; keys to or synopses of the genera of each family; descriptions of the genera; usually, keys to or synopses of the species of each genus; descriptions of the species. There may be many accessory parts, such as illustrations, descriptions of intermediate groups, geographical range, habitat, and notes of various kinds.

Students are assumed to have a knowledge of elementary morphology before attempting to use a manual. As in the case of any special work, a knowledge of the terminology is necessary. Much of the terminology is obtained from an antecedent course in elementary morphology. Manuals are usually supplied with a glossary giving the meaning of technical terms used in the work. Terms of special application in a family of plants are usually given in connection with the description of the family.

Since the student must learn to identify plants from descriptions, it is essential that he learn the exact meaning of technical terms. To save space in the work and to save the time of the user, the descriptions should be as concise as is consistent with accuracy.

Before attempting to identify a plant, the student should know thoroughly the structure of the flower, since upon this the classification is based.

In using a manual, the first thing with which the student comes in contact is a key to the families of plants. If perchance he knows the family to which the plant in hand belongs, he turns to the key to the genera. First of all, therefore, he must learn how to use a key. A discussion of the different kinds of keys will be found in Chapter XI. The keys in the manuals mentioned are all constructed on the same general plan, and the ones in Gray's " Manual " are typical of those in the other manuals.

Out of the numerous characters pertaining to the several species to be keyed out, an author, in devising a key, strives to select constant characters, and, as a rule, relatively conspicuous ones. Authors differ greatly in the characters they choose for their keys, and the student has to take keys as he finds them.

Let us now examine the key to families in Gray's " Manual." The families are first divided into two divisions, Pteridophyta (ferns and their allies) and Spermatophyta (seed plants). If the plant to be identified bears seed instead of spores, that is, if it is what is commonly called a flowering plant, the student will now consult the second division. The families of this division are again divided into two divisions, this time called subdivisions; the first, Gymnospermae, or the pines and their allies; the second, Angiospermae, including all the remaining families constituting the great bulk of the flowering plants. We will suppose that the student has in hand a strawberry flower. Having examined the plant, he knows that it belongs to a family included in the Angiospermae, which he notes are

divided into two subdivisions, these being of the third category, and called classes. The descriptions of the two classes show that the plant in hand belongs to the second class, the Dicotyledoneae. The groups thus far are natural divisions, based upon fundamental morphological characters. Now commences the key proper, in which contrasting characters lead by successive steps to the families.

In a long key like the one in Gray's "Manual," corresponding divisions may fall on different pages. The first division of the key reads "X: Corolla none; calyx present or absent Y." Since there are two corresponding divisions of the same category with contrasting characters, the student must search for the second division. This is found on page 15 and reads, "X: both calyx and corolla present n." He is led to this second division by the letter X, by the indentation, and, in this case, also by the bold-face type. As the strawberry flower has both calyx and corolla, the student knows that the plant belongs to a family included in the second division of the key. The letter n indicates that the next pair of divisions will be preceded by that letter. Thus the student goes to successive subdivisions of the key, deciding, from his knowledge of the structure of the plant, under which subdivision of the key he must look for the family to which the plant belongs. We may now pass rapidly down through these subdivisions. There will be chosen successively:

n. Corolla of separate petals.
o. Stamens numerous, at least more than 10.
p. Calyx entirely free and separate from the pistil or pistils.
q. Pistils several or many.
r. Terrestrial plants.
Not climbing.
Filaments not united.
Leaves alternate.
Stamens on the calyx.

At this point the key refers directly to the family Rosaceae. The student turns to page 454, where the family is

described, and he finds that the description applies to the plant in hand. He has now determined the family to which the strawberry belongs.

The next step is to determine the genus. By the system followed in Gray's " Manual," there is, under the family, a synopsis of the genera, in place of an analytical key based on one or few characters as in most manuals. In the case of the Rosaceae, the genera are arranged under seven tribes and it is necessary to read the characters of each to determine to which tribe the strawberry belongs. It will be noticed that the primary emphasis is placed upon the kind of fruit. Assuming that the plant in hand bears fruit or that the student knows the structure of the strawberry fruit, it will be seen that the plant must belong to the third tribe, Potentilleae, as this is the only one in which there are numerous achenes not inclosed at maturity. The arrangement of the genera under the tribes is essentially that of a key, though in the form of a synopsis, and the student soon determines that the strawberry belongs to the genus *Fragaria*, a conclusion confirmed by reading the description of the genus on page 479. As there are only two native species in the region covered by the Manual, each with one variety, there is no difficulty in determining the species.

In the use of the keys in identifying plants, the student is confronted with two difficulties, both based primarily on lack of knowledge and experience. The first is insufficient knowledge concerning the structure of the plant to be identified. This may be due to carelessness or laziness. It may be necessary to know how many cells the ovary contains. If the pistil is small it requires some skill and patience, and the use of a sharp knife and a good lens, to determine this point definitely. In regard to this difficulty it need only be said that one should determine definitely the structure of the plant to be identified, in so far as a knowledge of its structure is called for by the key. A more serious obstacle is encountered when the material at hand is incomplete. The plant may have only flowers, while some

part of the key calls for knowledge concerning the fruit, or vice versa. The only satisfactory means of overcoming this difficulty is to obtain complete material. The beginner is advised against attempting to identify plants from incomplete material in any case where the lack would interfere with the use of the key. Of course, many plants may be identified from the flowers alone. But one would encounter serious or even insurmountable difficulties in the Cruciferae and Umbelliferae without fruiting specimens.

The student with some experience may often be able to use the key for incomplete material, by trying both divisions of a key at those places where the answer can not be determined from the plant. With patience in checking up results by the descriptions in the text, he will probably succeed.

A second difficulty in the use of a key is inexperience in the use of technical terms; that is, the student may not thoroughly understand the meaning of a key statement and can not follow a definite route through the key with certainty. If a key character be " placentae parietal," he must know what this means. The meaning should not be guessed at. The glossary in a manual, or even a good dictionary, will define most technical terms.

In the foregoing it has been assumed that we are working with keys which present distinctly contrasting characters and which, with complete material and adequate knowledge of technical terms on the part of the student, enable him to reach his goal with certainty. However, other difficulties may be encountered, in addition to those already discussed.

As pointed out in a previous chapter, the innumerable plant individuals have not in all cases segregated themselves into entirely distinct groups. A species as accepted by a manual may be polymorphic; that is, it may include individuals showing considerable variation but connected by others to form a coherent group. On the other hand, two species as accepted by the manuals may be closely allied and there may be connecting or intermediate in-

dividuals, so that it is not easy to determine to which species a given individual belongs. Groups of closely allied species are often referred to as critical groups. The identification of plants belonging to such groups is always difficult, partly because of the student's inexperience and partly because of lack of knowledge on the part of the author of the manual. The student can lessen the difficulties by investigating the plants on his own initiative. He may study the plants of the group as he finds them growing, and note their variation — study the group, so far as it is represented, as well as the individual. Original work of this kind will be taken up in a later chapter.

The student should be warned not to take descriptions in the manuals too literally or too rigidly. The description is usually drawn from an average specimen or applies to average individuals. A reasonable allowance must be made for departures from the average. If a description covered all possible variations in a species it would become so involved or so indefinite as to lose value as a guide. If the student has at hand a large number of specimens, as will usually be the case when the plants are studied in the field, he will be able to determine the average for himself. But if he has a single individual and has no knowledge of the species otherwise, he should make allowance for departures from the average, especially in all kinds of measurements. If the description states that the height of the plant is 4 to 8 decimeters, he should expect occasionally to find dwarfs of 2 decimeters or giants of 12 decimeters. Abnormalities, that is, distinct departures from the normal, may also occur. A flower described as having 5 petals may occasionally have only 4; the 3-foliolate clover leaf may occasionally have 4 leaflets. The proper interpretation of descriptions comes with experience and the development of judgment.

The student should note habitat and range, as these data may aid him in interpreting the descriptions of closely allied species. By habitat is meant the situation and kind of soil in which the plant grows or the plant association in which

it is found. As examples of habitat may be mentioned the following: rich woods, prairie, swamp, marshes, meadows, forests, rocky slopes, shady river banks, cultivated fields, sandy soil, waste places. Not infrequently, closely allied species are found in distinctive habitats. By range is meant the geographical area in which the species is found. Closely allied species often have different or even distinct ranges. If the ranges of closely allied species coincide or overlap, the habitats are usually different. This is as one would predict from the accepted explanation of the origin of species. Two closely allied species presumably diverged from a common ancestor, and the divergence was favored and fixed by a difference in the surrounding conditions.

The habitat and range as given in the current manuals must be interpreted with some flexibility. The habitat there given is the usual one for the species in question. A species may occasionally be found growing under exceptional conditions. Due allowance, for example, should be made for the fact that conditions may change after a given perennial plant has become established in a particular place. A species growing normally in rich woods may persist after the trees are cut and the area converted into a meadow or a cultivated field. A species may persist in a habitat into which it would not have intruded.

The range of a species as given in a manual is based upon records of plants collected or observed, and must of necessity depend upon the completeness of representation and upon the accuracy of the observations. Extensions of range are to be expected in the less-known regions and may occur in well-known territory. Range is intimately connected with habitat. Unexpected extensions of range may depend upon the recurrence of a favorable habitat or upon some change of conditions in an earlier geologic period. Several species of the South Atlantic Coastal Plain have recently been discovered on Long Island and Cape Cod, but in the same habitat; that is, the Atlantic Coastal Plain conditions extend continuously or with slight breaks at

bays, from Florida to New Jersey, and reappear on Long Island and Cape Cod. Certain species of the Coastal Plain reappear at the south end of Lake Michigan. Alpine plants may be isolated on mountain peaks hundreds of miles from the main range of the species. Often erratic ranges of this kind are to be explained by the geologic history of the species. The geographic distribution of plants is a fascinating subject in itself and one with which the student of taxonomy should become acquainted. The subject is mentioned here only to draw the student's attention to the aid he may receive from statements of habitat and range in the ordinary course of plant identification.

Before leaving the subject of keys, the student should be reminded that in complicated keys, like the one to the families of plants, it is impracticable to note all exceptions. If all exceptions were included the key would become so vague that the beginner would be lost in a maze of uncertainty. Plants are not classified according to single characters but according to combinations of characters, or, as one author has said, " according to the totality of their morphological resemblances." A key, in order to be usable, must pick out one or two, or at most only a few, characters for distinguishing groups. The larger the groups to be distinguished the more likelihood there is of there being exceptions. Many keys provide for some of the exceptions by placing the same group, a family for example, in both divisions, or by segregating the exceptional small group, such as a genus, in the alternative division of the key. Even with this disposition of exceptions, there will be here and there other unusual cases which were not foreseen by the maker of the key or which, because of their rarity, were disregarded. On the other hand, the possibility that the student has in hand an exceptional case should not prevent him from using the key as if there were no exceptions.

CHAPTER VI

THE IDENTIFICATION OF PLANTS

When he has learned how to identify the plants of his locality by means of a descriptive manual, the student will have acquired the experience needed for a wider survey of the field and may now attempt the naming of plants from all parts of the world. The methods are the same, but the whole work is on a much larger scale. The student will soon realize that in this general identification he is in position to render fundamental aid to his colleagues and to laymen. Correct identification is at the very basis of all scientific work that depends in any way upon species of plants. It is also at the basis of much commercial work. The commercial value of many plant products depends upon their being obtained from a particular species. Too much emphasis can not be placed on the necessity of having definite and accurate knowledge as to the specific identity of plants that are used for any purpose, either scientifically or commercially. A large part of the work of a taxonomist consists, therefore, in identifying plants for the use of others. The taxonomist can tell of many puzzles submitted to him for solution. He is expected to identify seeds, fruits, woods, drugs and fibers, materials which can not be determined in the ordinary way but only with the aid of experience.

The chief difficulty for the student as he begins world taxonomy will be the multiplicity of books with which he must be acquainted in order that he may consult them when necessary. Only by experience can this difficulty be overcome. There is no flora of the world, and very few monographs of large families covering the world. There is no recent flora of a continent. In the present chapter will be given a few hints that may aid the beginner in choosing the

proper work for the plant in hand and in identifying the plant when the book has been obtained. It is essential that he have an elementary reading knowledge of Latin, German and French, for at this stage of his work he must deal with the floras of the world. There are a few important works in Spanish and still fewer, and these mostly of local scope, in other languages. However, in practice the student covers the regions of the earth in a general way through works in the languages mentioned. Even French can be dispensed with in most cases, because French authors have usually written in Latin, as was the custom in the early days of descriptive taxonomy. The English (and Americans) and the Germans have broken away from this custom to such an extent that now all botanists must be familiar with at least Latin, English and German.

The student's first experience in the general identification of plants may be obtained while he is serving as an assistant in botany at a college or an experiment station. Here he will receive, for naming, more or less fragmentary material sent in from localities with whose flora he is not familiar. Later he may obtain an appointment at an institution possessing a large herbarium, where, in addition to the routine curatorial work, he will do more and more identifying, passing from the ordinary to the critical as his experience widens.

The plants to be identified will, for the most part, fall into three classes: those from the United States; those from foreign countries; and cultivated plants, the native country of which may not be known to the student.

Plants from the United States

So far as concerns the first category, the student will be on familiar ground for a part of the time. Presumably he is acquainted with one of the manuals for one of the larger sections of the United States. For plants received from regions not covered by the manual he has been using, he may be able to turn to another one. The manuals listed in

Chapter V cover the eastern part of the country and the Rocky Mountain region. There remains the region from Texas and the Rocky Mountains westward.

"The Botany of Western Texas," by Coulter (Contr. U. S. Nat. Herb. **2** : 1–588. 1891–94) covers the portion of Texas west of that included in the range of Small's Flora, but unfortunately is rather out of date. "The Flora of New Mexico," by Wooton and Standley (Contr. U. S. Nat. Herb. **19** : 1–794. 1915), is helpful for that state and does very well for the adjacent parts of Arizona. "The Flora of the State of Washington," by Piper (Contr. U. S. Nat. Herb. **11** : 1–637. 1906), serves in the same way for Washington and much of Oregon, connecting on the east with the Rocky Mountain floras. The last two works, "The Flora of New Mexico," and "The Flora of Washington," have keys and annotations but do not have descriptions; hence it may be necessary to check results with descriptions from works referred to in the citations, or works in which the species to be confirmed is known to be described. For California we have the out-of-date "Botany of California," by Brewer and Watson (**1**: 1–628. 1876; **2** : 1–559. 1880). Some further help may be obtained in California from certain local floras, such as Abrams' "Flora of Los Angeles," Abrams' "Illustrated Flora of the Pacific States," Greene's "Manual of the Bay-Region Botany," and Jepson's "Flora of Middle Western California." Jepson's "Flora of California," is excellent for the few families in the five parts thus far issued. The region extending from Arizona through Nevada and Utah to southern Idaho is covered in part by the recent flora of Utah and Nevada by Tidestrom. The "Botany of the Mexican Boundary," by Torrey (1859), aids in identifying plants from southern Arizona.

However, one may, to better advantage, turn to works along systematic rather than along floristic lines. First of all is the "Synoptical Flora," by Gray, continued by Robinson, which covers the Gamopetalae. Then there are

revisions of genera and families scattered in journals and proceedings of scientific societies. These are too numerous to mention here and constitute that fund of recorded knowledge with which the student becomes familiar only through experience.

Plants from Foreign Countries

We may look first at those cases in which there is a descriptive flora of the region from which the plant in hand comes. On consulting the proper flora, the student identifies the plant in the manner outlined in the preceding chapter. In this case, however, he comes in contact with new sets of technical terms in English and must become familiar also with the technical terms of foreign languages, not all of which may be found in the dictionaries. In addition, he will encounter different methods of presentation, different styles of keys, or the absence of keys.

The literature available for consultation which concerns floras of countries of the world outside the United States is so extended that it would be impracticable to list it here. Some of the more helpful floras are listed at the end of this chapter. Here, again, experience must come to the aid of the student. He must learn not only where to go for information but also how to discriminate between the useful and the useless, or at least the less useful. In general, the newer publication is the more useful but there are many older works that still hold their own in certain fields, some because of original excellence, some because there are no recent works to replace them.

If the plant in hand comes from a region for which no descriptive flora has been written, the student must adopt a method of procedure differing from that described. In such circumstances, it is best to turn to a monograph or revision of the group to which the plant belongs, in cases where such a work exists.

To utilize a monograph it is necessary to know the systematic relationship of the plant. The student should at

the outset determine the family if this is not already known to him from his general experience. In his preliminary training while studying his local flora, he has probably come in contact with one hundred to one hundred and fifty families, which is about one-third to one-half the total number. Furthermore, among the families with which he is familiar are a large proportion of the great families of the world. It would seem, then, that only a small proportion of his cases will require the use of the general works. It is very necessary, however, that the student should be familiar with these works and should develop facility in their use. It is advisable at first to use the keys with known plants in order to learn the terminology and the author's method of presentation.

If the family is known, the student avoids the necessity of using a general key and may go at once to a work in which the family is treated. Unfortunately, there are recent revisions of only a comparatively few families. De Candolle's " Prodromus," begun in 1824 and continued until 1873, includes nearly all the Dicotyledoneae. The later families were treated in a much more elaborate manner than those of the earlier volumes because the number of known species had greatly increased. When the work ceased, the families first covered were already in need of revision, but the book is standard and even at this date may be helpful for some families. A later series of monographs is De Candolle's " Monographiae Phanerogamarum," in which several families are revised. The most recent work covering the entire world is Engler's " Pflanzenreich," which was begun in 1900 and has been continued to date.

The two works available for the determination of the families of plants of the world are as follows:

Bentham and Hooker. Genera Plantarum, 1862–83. This contains probably the best key to the families of flowering plants, but is somewhat out of date.

Engler. Syllabus der Pflanzenfamilien. This supports the parallel work by Engler and Prantl, the " Pflanzen-

familien," which contains no key to families. The " Syllabus " is a synopsis rather than a key. There are several editions.

Knowing the family, the student consults a monograph of that family, if such exist, either one covering the whole world or one for the region from which the plant comes. If no systematic account of the family is available, the genus should be determined from one of the general works mentioned above.

The problem before the student now is to determine the species of a plant coming from a country of which there is no descriptive flora, and belonging to a genus not included in a general taxonomic treatment. There is no recourse, so far as concerns the literature of the subject, save to seek the identification in round-about ways. Not infrequently, there are lists of plants of regions or localities of which no descriptive floras have been written. Such a list may suggest, if it includes the genus, the identity of the plant in hand. Floras of adjacent regions may include the species and should be consulted. In these cases the identification must be confirmed by consulting descriptions of the species. The descriptions are scattered and are found by consulting an index. The only general index to species is the " Index Kewensis."

The student should early learn to use this invaluable work. It is an index to the original descriptions of all flowering plants published since the proposal of binomial nomenclature, beginning with the publication of Linnaeus's " Species Plantarum " in 1753. The bibliographic references are abbreviated (see page 19). The native country of each species is also given, but only in a very general way, because of space limitation. The valid species, as recognized by the authors of the " Index," are given in roman type, the synonyms in italics followed by the species to which they are referred. The student is warned not to place implicit confidence in these references of synonyms as they represent only the opinions of the authors, opinions

not always based upon careful research. The real value of the work is in the bibliographic references. Since the publication of the original "Index" in the latter part of the nineteenth century, several supplements have been issued. The student should make a list of the species growing in the region from which the plant in hand came, the northern Andean region, for example. Some of the species of this list may have been eliminated at earlier steps in the search. The remainder of the descriptions must be consulted, one by one, until one is found that fits the plant.

Suppose, for example, the student has for identification a grass from Colombia which he knows to belong to the genus *Festuca*. There is no flora of Colombia that will aid him, nor is there a revision of *Festuca* that includes this region. In tropical America the genus *Festuca* is confined to high altitudes, this information being given in the general works that have been consulted in determining the genus. The great work on South American botany, Martius' "Flora Brasiliensis," is of little aid in determining plants of the Andes, especially those of a country so far removed from Brazil. Gay's flora of Chile may be consulted, but only a few Chilean plants reach so far north as Colombia. The work most likely to be helpful is the familiar "H.B.K." (Humboldt, Bonpland, and Kunth's "Nova Genera et Species, etc."), which contains an account of the plants collected by Humboldt and Bonpland in their journey through Mexico and the northern part of South America in the latter part of the eighteenth century. Descriptions of the more common mountain grasses are likely to be found in this work. In case the grass in hand is not described here, the student must settle down to a patient search. Coast species are sometimes found in Grisebach's "Flora of the British West Indies," but mountain species rarely. It is often worth while to consult the "Biologia Centrali Americana." Descriptions are not given in this work, but bibliographic references for the included species enable one to find the original descriptions. Since some Mexican mountain

grasses extend into Colombia, the student should look up the genus *Festuca* in Hitchcock's account of Mexican grasses (Contr. U. S. Nat. Herb. **17** : 1913). At this stage in the investigation, it is well to consult Steudel's "Synopsis Graminearum," which gives descriptions of the grasses known up to about the date of publication (1854). This work is scarcely more than an assemblage of compiled descriptions, without keys, and with only meager mention of range. Nevertheless, it may put the student on the track of the description sought.

In looking up a genus in an old book, one should keep in mind that generic concepts have changed with the passing of years. It happens that the concept of the genus *Festuca*, referred to above, is much the same now as in the time of Linnaeus, differing only in the larger number of species at present known. But if the student attempts to look up in an old work a familiar species of *Eragrostis* he will probably find it included under *Poa*. A species of *Muhlenbergia* might be found under *Podosaemum*, a species of *Chaetochloa* or *Setaria* under *Panicum*, and so on. One must take taxonomic history into consideration when using the older works.

One becomes more or less familiar with generic synonyms in the course of work. Most of the generic synonyms are listed in the "Index Kewensis," Dalla Torre and Harms' "Genera," and Bentham and Hooker's "Genera," each under the valid genus to which it is referred. Such synonyms are not to be taken as referred without verification, but they give a clue.

In his search for the isolated descriptions cited in the "Index Kewensis," the student comes in contact with several papers dealing with the grasses of the Andean region, notably some by Pilger and by Hackel. He should record for future reference the titles of these papers. It is thus that his experience is enlarged and his facility developed. If the species at hand is known to science, he should be able to identify it in the manner described.

Cultivated Plants

The third category of cases previously referred to, the identification of cultivated plants whose native country is unknown to the student, involves a method of procedure which does not differ materially from that described under the second class. Fortunately, there is a comprehensive work treating of cultivated plants, Bailey's " Standard Cyclopedia of Horticulture." The first volume contains a key to the families and genera, the genera being alphabetically arranged. Here will be found described practically all of the plants sold by seedsmen and nurserymen. A more recent book of the same character is Bailey's " Manual of Cultivated Plants." In botanic gardens and in some of the larger greenhouses, specimens will be found that are not included in the Cyclopedia of Horticulture. For these one must resort to the general methods described in preceding paragraphs.

No reference has thus far been made to a very important adjunct in identification, namely, the herbarium. The student should use the herbarium for comparison and confirmation. Comparison may be the quickest means of identification, but the results should be checked by descriptions. Specimens in herbaria not infrequently bear incorrect names. The origin of the specimen and the authority for the name on the label should be taken into consideration. If the sheet or label bears an annotation indicating that the specimen has been identified by a competent specialist, one may feel confidence in the correctness of the name on the label. If the group to which the species belongs is a critical one, it is well to verify the comparison with a description. If the herbarium specimen under comparison belongs to a numbered set, it may have been cited in a revision or monograph of the group. Such citation gives weight to an identification, but one must guard against errors, such as the distribution by collectors of more than one species under a single number (see Chapter VII under Notebook).

Identification by comparison with herbarium specimens should be made with care. In critical groups, a casual examination may give the impression of identity when in reality the specimens compared belong to different though, it may be, allied species. The inexperienced student must take the greatest care to guard against error through a hasty judgment.

Short List of Foreign Floras

At another place (Chapter IX) the author has referred to the methods by which one searches out the floras of particular regions, that is, by consulting the library of the institution at which one is located. The floras are arranged geographically according to a system, that of Dewey, for example; and the student will here find a representation, large or small, according to the size of the library.

The list below is not intended to be a bibliography. It is only a suggestion for the beginner. Besides Nyman's "Conspectus," which is a somewhat out-of-date list of species, only Ascherson and Graebner's "Synopsis" has been mentioned under Europe. This covers a larger area than any other recent flora, and gives references to European species outside its range. These references will direct the student to the floras of other countries that it may be desirable to consult.

The following list embraces a few of the more recent floras of the chief regions of the world outside the United States and Canada. Descriptions are included except where otherwise stated.

AMERICA

HEMSLEY. Biologia Centrali-americana, Botany. Annotated list.
GRISEBACH. Flora of the British West Indian Islands
MARTIUS. Flora Brasiliensis.
REICHE. Flora de Chile.

EUROPE

NYMAN. Conspectus Florae Europaeae. Annotated list.
ASCHERSON AND GRAEBNER. Synopsis der mitteleuropäischen Flora.

AFRICA

Durand and Schinz. Conspectus Florae Africae. Annotated list.
Dyer. Flora Capensis. A Flora of South Africa.
Oliver and Prain. Flora of Tropical Africa.
Muschler. A Manual Flora of Egypt.

ASIA

Ledebour. Flora Rossica.
Hooker. The Flora of British India.
Forbes and Hemsley. An Enumeration of all the Plants Known from China Proper (Journ. Linn. Soc. Bot.). Annotated list.
Lecomte. Flore Genérale de l'Indo-Chine.
Merrill. An Enumeration of Philippine Flowering Plants. Annotated list.
Post. Flora of Syria, Palestine and Sinai.

AUSTRALASIA

Bentham. Flora Australiensis.
Miquel. Flora Indiae Batavae. A flora of the Dutch East Indies.
Cheeseman. Manual of the New Zealand Flora.
Hillebrand. Flora of the Hawaiian Islands.

CHAPTER VII

THE PREPARATION OF A LOCAL FLORA

Of the several kinds of taxonomic work leading to publication, three may be treated in detail as illustrating progressive steps in technique: the preparation of (1) a local flora; (2) a manual, or descriptive flora; and (3) a revision of a taxonomic group. The local flora, being the least complicated, will be considered first.

The term local flora is here used to designate a list of local plants, with or without notes, and without formal descriptions of genera and species. The simplest kind of local flora is a mere list of species, unaccompanied by notes. Such lists serve as a record but are of limited usefulness. When one makes the effort to prepare a local flora, it is well worth while to extend this effort so as to include notes that will serve as a record, not only of species, but also of facts about them, and will be an aid to the student who uses it.

The notes include habitat, distribution within the local district, general distribution, time of flowering, common names, and various annotations of local interest. Keys are a useful addition. These matters will be discussed in detail in later paragraphs.

Preliminary Work

A vast amount of work must be done before the flora can be written. The writing is the culmination of the work. The data must be painstakingly collected, usually over a series of years. Let us suppose that the area to be covered is the vicinity of the home of the worker. The region blocked out depends upon physiographic factors; but where a single individual is interested, the area is likely to be that easily reached on foot or by trolley lines and private conveyances. If the topography permits, this area will be

roughly a circle with a diameter of 5 to 15 miles. The "Flora of the District of Columbia" covers a circle with a 15-mile radius; the "Flora of New York City" covers a circle with a 100-mile radius; the "Flora of New Jersey" covers nearly all of the state. Piper's "Flora of Washington," Wooton and Standley's "Flora of New Mexico," and Mohr's "Plants of Alabama" are, as to plan, local floras state-wide in scope. The student of taxonomy who is beginning his work along these lines will usually select a smaller area extending only a few miles from his headquarters. A physiographic unit, such as the drainage basin of a small lake, a region of sandhills, or a swamp, furnishes the basis for an ecological study in connection with the flora.

We may now discuss the work in greater detail, supposing that the geographic limits have been fixed. The method of procedure will be much the same whether the worker be student, amateur or professional.

Herbarium. — Since the basis of the work is a knowledge of the species present, the critical identification of these becomes fundamental. To identify accurately, the student must study the plants in the field, making ample notes. Field study, while of first importance, is not sufficient, since many problems demand re-examination and comparison of two or more related forms. The plants should, therefore, be collected and preserved for reference in an herbarium.

Even though the worker have access to a general herbarium, it is advisable to preserve a special collection of plants involved in the work undertaken, as such a collection stimulates interest and facilitates comparison. Such a local herbarium has the advantage over a general one in that it is possible to make it much more complete, representing the range of variation of the species, their various phases, winter rosettes or winter buds, flowers, fruit, underground parts, seedlings, dwarf forms, abnormalities, and the like. Photographs showing the habit of the larger plants and others showing the habitat and plant formations and societies are very useful additions.

The herbarium sheets are a convenient place for recording notes about species and should be utilized abundantly for this purpose. Extra flowers, fruits or seeds, or parts of plants dissected may be preserved in small envelopes attached to the sheets. Drawings of dissections or sketches of the form of the flowers when fresh are most helpful.

Notebook. — In preparing an herbarium one should keep a field notebook. Each specimen intended for the herbarium should be assigned a number. All the specimens of a species collected at the same time (duplicates) receive the same number. One should avoid giving the same number to collections of the same species made at different places or on different dates. It is easy to connect different collections of the same species by a note (such as, 732 = 677). When, because of size, more than one sheet of a single individual is prepared, the sheets may be distinguished by letters, as, 642*a*, 642*b*, 642*c*. The use of *a*, *b* and *c* for different collections of the same species should be avoided.

It is recommended that every collection of a species that is preserved be given a number, and that the numbers, from year to year, be kept in a single series. The practice of numbering separately for each year or for each exploring expedition is likely to lead to confusion. Care should be taken to avoid errors in numbering, such as omissions or duplications. The author has found it helpful to number his notebooks in advance with a numbering machine, allowing sufficient space for notes — in a book of the usual size, three numbers to the page.

The collection number is placed on the sheet containing the specimen in the plant press, or is attached to the plant itself. Under the same number in the field-book are recorded the notes concerning the plant. These include primarily date, location and habitat. In addition, all data not shown by the specimen itself should be included. If the whole plant can not be collected, the size and habit should be noted. In studying trees, shrubs or half shrubs (such as blackberries), it is necessary to collect from the

same individual two or three times in a season in order to obtain flowers, fruit and different phases of foliage. These individuals should be marked in some way. The most certain way is to fasten to each of them a thin copper tag upon which a number can be impressed with the point of a knife or a nail. These tags can be purchased from seedsmen. Wooden plant-labels may be used; or, if the collector is not provided with any sort of tag, small holes can be made in the bark with the point of a knife, and the arrangement of the holes copied in the field-book beside the number. It is well to record the color of the flowers, as not infrequently the color changes in drying. Critical notes on variation are always desirable. Much or all of this information recorded in the field notebook ultimately appears on the label of the plant in the herbarium. Usually, the collecting is done in the growing season and the plants are mounted, labeled, and arranged during the winter. The date, of course, serves for the series collected on the same day and may be placed at the beginning of the series for that day.

Locality. — In a local flora, the locality should be given in sufficient detail to enable the collector to visit the same place again for further observations. It is very helpful to have a good local map. The localities can then be indicated by guide figures, as is done in atlases. If there is no suitable map of the region, the worker would do well to prepare one. If he can afford the expense, the map may be reproduced by the zinc-etching process and a fresh map may then be taken into the field on each trip and the collections located on the map.

Habitat. — One of the most interesting phases of work on local flora is the study of the relation of plants to their environment. The habitat should be carefully and fully noted. The kind of soil, especially in relation to water, the exposure, and the plant societies are all of importance. When the plant grows in a recognizable society, it is well to give the names of some of the leading associated species.

Local Range. — This evidently can be determined only by repeated observations. Ultimately the collector will have data upon which he can base a statement concerning range in the region covered by his flora. In many cases the range is determined by definite physiographic conditions, such as swamp, rich moist woods, or prairie. In other cases the species is rare or infrequent and its range can be determined only by an extended series of observations. It is interesting and helpful to plot the range of the different species on individual maps.

Abundance. — The range of a species has no close connection with its abundance. A species may be widely distributed and still be infrequent, or it may have a limited range but be abundant in certain places. In noting the distribution and relative concentration of the individuals of a species, one should choose a set of terms to indicate the degree of the intensity of distribution, for example: common, widely distributed over the area in large numbers; abundant, large numbers in certain areas, as, abundant in moist low woods; frequent; infrequent; rare. The terms given indicate progressively decreasing frequency.

Time of Flowering and Fruiting. — Most plants produce flowers during a fairly definite and limited period. For early spring-blooming species this period varies from year to year according to climatic conditions. An interesting and useful chart may be prepared by noting for each species the earliest date on which flowers were seen. By continuing the observations through a series of years and recording results on the same chart, an average for the locality may be deduced. The end of the flowering period is less easily determined, as the disappearance of flowers makes less impression on the observer than their first appearance. It is well to check off definitely the end of the flowering period of each species and to keep under observation particular individuals or groups. Some individuals produce flowers sporadically after the close of the regular flowering period. Other species continue to produce flowers during a greater

part of the growing season. Certain small species may produce flowers during the winter when the weather conditions are favorable for a few days. This is particularly true of intermediate latitudes. In the north, vegetation is entirely interrupted during the winter; in the south, vegetation may be only retarded during that period.

In connection with a study of the flowering period the observer may add much to our knowledge by noting the period of anthesis for individual flowers. Some flowers open and close more than once; some are ephemeral; some remain open for several days. The time of day at which the flowers open and close should also be noted.

Observations on the flowers pass easily and insensibly into observations on the fruits. With many plants the period of fruiting is fairly definite, varying somewhat with weather conditions. Thus it is with the strawberry and the walnut. Those plants, such as the mullein and plantain, that produce flowers successively through a considerable period, produce fruits in the same way.

Seed Dispersal. — Our knowledge concerning seed dispersal is not at all complete. The local observer will be able to record facts that may be of use to investigators far from the area studied. A careful study of fruits and seeds has never been made in connection with a local flora in this country.[1] It is advisable to add to the herbarium fruiting specimens of each species. It is also desirable to make a study of the morphology of the fruits and seeds and of the methods of dispersal, and, as far as possible, of the connection between the two.

A valuable addition to a local flora would be a key to the species or even to the genera, based on fruit characters.

Germination and Seedlings. — Much has been written upon both of these subjects, but much remains to be investigated. The author doubts if a systematic study of

[1] The author prepared a key to the genera of plants of Manhattan, Kansas, based upon fruit characters; but the work did not include a description of the fruits of all the species and did not discuss in detail the methods of dispersal.

these subjects has ever been included in a local flora. There are often interesting adaptations for releasing the cotyledons from the seed coat. The time of germination is of importance. Some seeds germinate soon after maturity; others require a period of rest. Some will endure extremes of drouth; others suffer if dried at all. There is usually a connection between the conditions favorable to germination and the adaptations for dispersal. It is well to have specimens of seedlings in the herbarium. Few botanists are able to recognize any considerable number of species in the seedling condition.

Vegetative Propagation. — One should note which species are annuals, which are winter annuals or biennials, and which are perennials. The perennial herbs may form crowns from which buds arise each spring, or they may produce propagating organs such as rhizomes, tubers, bulbs and stolons. Some of the woody plants may propagate from underground parts. Not infrequently, plants propagate themselves by adventitious buds upon the roots. A full discussion of the underground parts of the plants of a given region would be a valuable contribution to plant morphology.

While studying vegetative propagation one may observe other adaptations for passing the winter, in addition to those connected with propagation. The formation of crowns has been mentioned. Another adaptation for this purpose is the production of rosettes. These are found particularly in winter annuals and biennials, but also, in a modified form, in many perennial herbs, such as asters and goldenrods, in which the leaves of short shoots survive the winter.

Winter Buds of Woody Plants. — The observer will have studied the buds of herbaceous perennials while examining the underground parts as outlined above. The study of the buds of woody plants is a fascinating subject in itself and much more has been written upon it than upon some of the other subjects referred to above. However, the author does not recall a local flora in which it has received

detailed attention. A key to the species of the woody plants, based upon bud characters, would be a valuable addition to a local flora.

Opening of Buds. — The study of buds during the winter naturally suggests observations upon their development in the spring. One may note the vernation, the gradation between bud scales and leaves, and especially the morphology of the bud scales. For example, the stipular nature of many scales can be most easily demonstrated by observations upon the opening buds.

Pollination. — The subject of pollination has received wide attention, but no local area has been covered in respect to this subject and any local observer can add to the store of knowledge. If the observations include the relations of flowers and insects, the worker will need to submit the insects involved to an entomologist for identification.

When sufficient data have been gathered, the results are put on record in the proposed local flora. We will assume that the flora is to be an annotated list of the species with keys. If there is a general descriptive flora covering the region, the author of the new flora may, for convenience, take the existing one as a guide in the sequence of genera. He may wish to express personal judgment in the arrangement of the species. If there is no general flora available as a guide, he may, to advantage, follow Engler and Prantl's " Pflanzenfamilien " for the sequence of families and genera. Of course, if he wishes, he may present a new arrangement of families or genera, but this is not advisable in a local flora. A new arrangement should be based upon extended morphological studies and should be published with a view especially of presenting the results of these studies.

Plan of Flora

Let us suppose that the plan of the flora provides for an introduction, a key to families, and a classified list of species.

Introduction. — In practice, the writing of the introduction is usually left to the last. Here one gives the scope of

the flora, the area covered, the topography, geology, physical geography, and climate of the region. A map is always helpful. If the region has been studied by earlier botanists the botanical history may be referred to. In the introduction there is opportunity for the play of the individuality and initiative of the author. The beginner is advised to resist the temptation to speculate too freely upon insufficient data, especially as to the origin of the flora of the region.

Key to the Families. — The preparation of this key is also likely to be deferred until the body of the work is completed. For the technique of the preparation of keys in general, the student is referred to the section devoted to that subject (page 104). The author of a new key will doubtless use other keys to families as guides, the one in Gray's "Manual," for example, if the flora is within the region covered by that work. But the key can be modified and simplified because of the smaller number of families and the absence of exceptional genera which complicate the larger key. In a local flora one may, and in general should, base all the keys upon the included species. One does well to choose the more conspicuous contrasting characters in the key subdivisions. It may happen now and then that the only species of a genus, or the only genus of a family, represented in the flora is an exception to the group in general. The key in such cases would diverge sharply from the corresponding key in the more general work.

A convenient mechanical method of preparing the key is to write upon cards or slips the names of the families represented in the flora and divide these into groups corresponding to the division of the key. In this way no family will be overlooked. Occasionally it may be expedient to have a name appear in each subdivision. A duplicate slip is then inserted in the series. It is well in this case to note on the slip the reason for the duplication so that the name may be provided for in the proper place.

The key is intended primarily to assist in identification. With a dichotomous key in which the most prominent distinguishing characters are selected for contrast, the key will unavoidably be an artificial rather than a natural one. The

families in the key will not always be brought together in their natural relationships. Nevertheless, when it is possible to do so without sacrificing definiteness and simplicity, it is well to choose for key characters those based upon natural affinities. This is especially true of the first few primary divisions of the key. One should, for example, separate the monocotyledons from the dicotyledons, and, if practicable, the Gamopetalae from the Choripetalae. On the other hand, one does well to avoid minute or inconspicuous characters, even though these be fundamental, if other more easily recognizable characters are available.

Classified List of Species. — The following remarks are presented only as suggestions. There are many ways, equally good, in which this part of the work may be prepared. Emphasis is placed only on the desirability of formulating a definite plan and of following this plan consistently. The student should examine floras of the class he proposes to prepare and obtain suggestions as to style.

The families may be numbered in natural sequence, the botanical name of each being followed by its common name. Usually no notes appear in connection with the family unless the work is designed to be a descriptive flora. The author may, however, place here such notes as he thinks may be helpful or interesting to the user, such as those on buds, fruits, seed dispersal, and the like, not usually found in manuals.

Following the family name and the accompanying notes, if any, will be placed the key to genera of the family if there is more than one genus. Then come the genera in natural sequence, usually numbered separately for each family. The generic name should be followed by the authority, as "*Salix* L." The common name for the genus may be given when there is one that is generally recognized, as "*Salix* L. Willow, or the willows." Some authors give the citation for the original publication of the genus and also of the species. This, however, is practicable only when the work is done in connection with a well-equipped library and by a

person with experience in bibliography. If the citations are merely copied from other works without reference to original sources, there is little to be gained by including them. Unverified copying of citations gives the reader a false impression of bibliographic research. The same may be said of synonyms. If the flora follows a manual, one may consult that work for synonymy. If no manual is available as a guide, one may include synonyms where these would aid the user in coördinating the names with those given in other floras. In general, synonyms are to be introduced only when there is a real need for them (see section on synonyms, page 124).

Under each genus may be given notes applicable to the species included, similar to those given under the family; a key to the species may also be given if more than one species is included. The species may be numbered consecutively through the family but are usually numbered for each genus. The species names appear with the authority. Common names for the species are of importance. It is well to select one name for the species to follow the main heading, and to mention other names in the notes. Local common names are often of interest.

The most important contribution to science will be the notes given under each species. The author should decide on the sequence of presentation and follow this plan throughout. Usually, one gives first the habit, then the local distribution, followed by the flowering period. Then, as a separate paragraph, are given miscellaneous notes which may constitute a record of original observations of prime importance. Here would come notes on the subjects mentioned in the first part of the present chapter, such as seed dispersal and pollination.

If the notes that have been taken are sufficiently comprehensive, it may be well to include them in a separate chapter or appendix. For example, the author might give a supplementary key to the woody plants, based upon bud and twig characters, or a key to the genera, based upon fruit

characters. An account of seed dispersal or of the opening of buds might be included in the introduction.

The value of a local flora depends upon accurate identification of the species. The author of such a work will do well to submit to specialists his specimens of plants belonging to genera in which identification is difficult. On the basis of critical identification, the local botanist has an opportunity to work out the relationships of species in such a manner that his conclusions will form a valuable contribution to systematic botany. The work then becomes one in which the specialist, who knows the problems and the difficulties, coöperates with the field worker, who is in a position to solve the problems and remove the difficulties.

In general, one should avoid the publication of new species or of new combinations of names in a local flora. The chief objection is that new names are not usually sufficiently accessible to indexers and they may be overlooked. This objection is of less weight if the flora is published in the transactions of a well-known scientific society.

CHAPTER VIII

FIELD WORK, HERBARIUM AND LIBRARY

The published results of advanced taxonomic studies are based upon investigations extending over a considerable time and involve much work in field, library and herbarium. Before discussing the form of the published records it will be well to consider the methods used for gathering data. The real study expended upon the subject is done in bringing together the data; the publication is merely the orderly arrangement of results for permanent record. Taxonomic data are obtained chiefly from three sources, the field, the herbarium and the library. The living plants are observed in the field[1] or garden. For convenience in the comparison of plants from different localities, they are dried and preserved in an herbarium or brought together and cultivated in a garden. As in all branches of science, it is necessary to consult the records of other workers upon the same subject; hence recourse must be had to the library. By far the greater part of taxonomic work is done in the herbarium and library. Few taxonomists are so situated that they can spend in the field the time necessary for collecting any considerable proportion of the data needed in their work. Hence most taxonomists must study, in the herbarium, plants that have been collected by others. Yet the modern student of taxonomy makes every effort to spend some time in exploration or field work, in order to become as familiar with the plants of the group or region he is studying as circumstances permit. Plants from relatively inaccessible regions are, for the most part, collected and distributed by professional collectors, or at least by botanists who are

[1] The expression "in the field," is used by botanists to indicate any place where the plants to be observed are growing naturally.

making general collections for the benefit of their fellow workers. The detailed discussion of the methods of study may be most conveniently considered under the three subdivisions mentioned, the field, the herbarium and the library.

Field Work

Field work for the taxonomist has two purposes, observing and collecting. Observations upon plants in the field are of prime importance in training the taxonomic judgment. One can here examine large numbers of individuals and note the variation among those that constitute a single species. One can also note the effect of environmental factors, such as differences in the amount of light and moisture, exposure, soil, and physical factors in general. One notes the habitat, the associated species, the plant societies. Furthermore, one may observe habit characters which, though conspicuous in the field, may be obscure in the herbarium. It is especially necessary to note habit characters in large plants, which are represented in the herbarium by small parts only. So far as possible, it is advisable to supplement the notes by photographs.

In the matter of specific limitations, the experienced taxonomist can usually form conclusions satisfactory to himself, when observing the plants of a given area. If he is studying the species of a critical genus, he can say with some definiteness, when observing a given area, that such and such species are found there. His chief difficulties are encountered when he attempts to compare two separated areas. But his notes on the variation in a group of individuals which, in his judgment, belong to the same species is a distinct aid in interpreting the relations of individuals in the herbarium.

In order to have records which will connect his field notes with the species studied, the taxonomist preserves specimens to confirm or identify his notes. The collections made in this way are the chief data of the specialist. It is rarely

practicable for one to observe in the field all the species of the group he is studying, or to visit more than a small part of a region the flora of which he is preparing. He must resort to the miscellaneous collections in the accessible herbaria.

The collection of botanical specimens involves certain matters of technique to which attention must be given if satisfactory results are to be obtained. Reference has already been made (page 45) to the collection of specimens and the recording of notes during the preparation of a local flora, and the taxonomist is assumed to have learned the elements of collecting plants for an herbarium. We may, therefore, now consider the technique of collecting as practiced in the course of a journey undertaken for this purpose. For convenience and economy, the collector will reduce his paraphernalia to a minimum. The methods outlined here can serve only as a basis for discussion and must be varied to suit the special conditions to be met in specific cases. Let us suppose that a taxonomist wishes to prepare for a trip of three months, that several stations will be visited, and that ordinary flowering plants are to be obtained in a single series, with casual duplicates.

It is convenient to have a trunk of a size to hold standard driers. The present author has used one that is 3 feet long, 18 inches wide, and 12 inches deep below the tray. This space accommodates driers, inner paper, presses, and bundles of plants, without waste space. The collector should take 300 to 500 standard driers, inner sheets corresponding to the number of specimens he expects to get, 3 slat presses with straps, and a field press or portfolio. Other items are notebooks, marking crayons, a supply of pencils, and twine. The author always has a supply of manila slips for holding the bent stems of grasses. These slips are made from old genus covers, postal cards, or paper of like weight, cut about 3 inches long and 1 inch wide with a slit about the middle. They are very helpful in preparing good specimens of grasses and grasslike plants.

Each collector develops a method of field technique which satisfies best the conditions of his particular problem. The author will describe his own methods, not with any suggestion of their superiority but with the hope that in some respects they may prove helpful. He follows the customary method of carrying a field press with a supply of inner papers — stock newspaper, cut to the size of mounting paper. For most grasses he uses single sheets. Double sheets or folders are used for all plants which need protection. Plants having adhesive fruits, delicate flowers, or easily detachable parts need folders. The advantage of using single sheets where practicable is the economy of paper and especially the saving in weight of paper to be carried in the field press. The plants are disposed on the inner sheets as they are to appear in the mounted specimen. For digging up plants the author uses the small pick supplied by dealers in botanical outfits. The collector should obtain representative parts of plants, such as rhizomes, and leaves of different kinds.

The notes accompanying specimens are of great importance. The author uses a notebook, placing his notes under numbers, with corresponding numbers on the sheets of specimens. Some collectors prefer field labels, these being especially useful when one employs native helpers who have no special knowledge of botany. The field labels may be printed blank forms to be filled in by the collector. The notes should be recorded in the field for each specimen as collected. When much pushed for time, as when traveling by horse in new regions, the author has recorded the notes in the book as the plants were placed in press. He aids his memory when necessary by notes made on the sheets while gathering the specimens. When the specimens are put in press the number is written on the sheet with a soft marking crayon, which makes a wide, distinct mark on paper. The notebook is numbered at home, before the journey is begun. A numbering machine is used for this purpose, three numbers being placed on a page. This division of the page gives

sufficient room for notes. Some space is wasted in this way but the disadvantage is offset by the greater convenience and especially by the insurance against mistakes in numbering. The author uses a single series of numbers.[1]

In wet regions, such as tropical rain forests, the ordinary drying methods must be modified. The author has found the following procedure to be practicable. He carries, in place of a part of the drying paper, a supply of corrugated paper faced on one side, the number of sheets (cut the same size as driers, the corrugations running crosswise) depending on the amount of drying to be done — usually 50 to 100 sheets. The specimens are first placed between driers in the usual way and strapped in a press for twelve to twenty-four hours. This is to flatten them so that they will not wrinkle during the drying. Then the inner sheets with the specimens are placed between corrugated sheets, the driers being omitted, and the bundle strapped moderately tight but not so tight as to crush the corrugations. The bundle, preferably not over a foot thick, is supported (the corrugations vertical) over a kerosene lamp with a broad (about 4-inch) wick, such as is used for cooking. Cloth is draped around the bundle and lamp to form a protection to the lamp and a chimney for the heat. It is well to surround the lamp with a wire netting to prevent the cloth from touching the lamp. The distance of the bundle above the lamp should be such as to produce the maximum heat without charring the paper. Most plants will be dry in twelve hours; succulent plants require a longer time. Kerosene lamps or stoves can be obtained in the towns of nearly all countries, and kerosene oil is available in all except very remote districts. In the absence of oil, one can use the same method over a wood fire but constant attention is needed to prevent burning the plants. With kerosene stoves this process can be kept in operation constantly, day and night, and additional stoves can be used if needed.

[1] This series was commenced in 1906 and has now reached the twenty-third thousand. The collections consist mostly of grasses.

When the plants are dry they are packed in bundles, the specimens still lying on or in the inner sheets. Except in dry climates, a little naphthalene powder should be put on each specimen to preserve it against mold and insects. In wet regions it will be necessary to dry the bundles occasionally, as they absorb moisture.

The Herbarium

The herbarium is a collection of dried specimens arranged in cases in orderly sequence for consultation. In the modern herbarium the specimens are mounted, that is, fastened to paper of uniform size. The standard size sheet is 11½ by 16½ inches and the weight of the paper is sufficient to support the specimen properly. The dried plant (speaking now of phanerogams) is attached to the sheet by glue or by strips of gummed cloth, and a label, upon which are given the name and the data from the notebook, is placed in the lower right-hand corner. Detached parts, such as seeds and fruits, are placed in small packets that are fastened to the sheet.

The mounted sheets are placed in genus covers of heavy manila paper bearing the name of the genus in the lower left-hand corner, and the covers with their contained specimens are arranged in herbarium cases. The standard herbarium case contains twenty-four pigeon-holes in four vertical rows, with two doors hinged at the sides of the case. The best cases are made of steel. Wooden cases may be sheathed with sheet metal to protect them from fire, and may be lined with sheet tin to aid in fumigation. The standard unit cases may be arranged in rows with table tops for use in consulting specimens, or can be placed one over the other and still be accessible from the floor. A third series may be placed above these for duplicates and storage, but these can only be reached by means of a step ladder.

Herbarium specimens are subject to the attacks of insects and must be protected. Some curators poison the specimens before mounting, by dipping them in an alcoholic solution of

corrosive sublimate. Others depend upon periodic fumigation with carbon bisulphide. Naphthalene is a deterrent and may be placed in the cases in the form of sticks, balls, or flakes. In some herbaria, all incoming bundles of plants are fumigated in a special case. For fumigation in the herbarium it is necessary to render the cases airtight by lining them with sheet tin soldered at the seams, and by the use of outer doors or covers with felt joints.

In a large herbarium the arrangement of the plants assumes importance. The usual method in America is to arrange the genera according to Dalla Torre and Harms' work on genera, "Genera Siphonogamarum." In this work the genera of flowering plants are numbered in sequence, and the corresponding numbers are placed on the genus covers in the herbarium. Interpolated genera may be given the additional letters *a*, *b*, *c*, etc.

The species of each genus are usually arranged alphabetically. Theoretically, the species should be arranged in natural order, as are the genera, but convenience in the use of the herbarium must be considered. The sequence of the genera is fairly fixed, at least for a few years at a time, until a revised list of genera is published. But the species, except for monographed genera, have no fixed arrangement and there is no comprehensive list of the species of the world. In special cases the species of a genus may be arranged in systematic order for the purpose of comparison during a study of that genus. Species so arranged should be accompanied by an alphabetical index. The distributing of the specimens in a large herbarium is much facilitated by an alphabetical arrangement.

It is usually found convenient to segregate the species of each genus along geographical lines of some kind, the limits differing in different herbaria and in different countries, the determining factor being ease of consultation. In American herbaria there is usually the segregation into Eastern Hemisphere and Western Hemisphere. The Western Hemisphere may be still further divided into United

States and northward; Mexico, Central America and West Indies; and South America. The subdivisions may be indicated by different colored genus covers or by the name of the subdivision on the cover. In the Grass Herbarium of the National Herbarium (see page 166), the subdivisions and colors are as follows: United States and northward, plain manila covers; Mexico to Panama, red covers; West Indies, blue covers; South America, yellow covers; Europe, gray covers; Asia, green covers; Africa, chocolate colored covers; Australasia, orange covers. Regional specialization of the grasses of the Old World might require further subdivision of some of these areas. The Field Museum has an elaborate system of colored covers for the larger floral areas of the world.

Specimens or parts of specimens that are too thick to be mounted on sheets may be placed in boxes the size of genus covers. These boxes are placed in the pigeon-holes as near the systematic position of the contained specimens as practicable. The thickness of the boxes varies, but they must not be deeper than the height of the pigeon-hole. In these boxes are placed large fruits, stems, cactuses, and similar bulky parts. Each specimen should be properly labeled and should bear a reference to the herbarium sheet which it supplements in case there is such, and the herbarium sheet should refer to the corresponding box.

The genus covers bear the numbers given by a standard list, the one in common use now being Dalla Torre and Harms' list as mentioned previously; and the genera are found in the herbarium by consulting the alphabetical index of that work. It is convenient, however, to have a card index to the genera, in which can be inserted genera published after Dalla Torre and Harms' list was issued.

Large herbaria often contain, besides the general collection, other special collections, such as a local herbarium and acquired private herbaria that for various reasons are not incorporated in the main collection. At the Paris Herbarium (Jardin des Plantes), the Michaux Herbarium,

the Lamarck Herbarium, and some others are segregated; at the Berlin Herbarium, the Willdenow Herbarium is kept separate; and at the British Museum, the collections of Walter, Sloane and others. The specimens of these special collections are more easily consulted because they are segregated, and deteriorate less rapidly because they are handled less.

In herbaria where the type concept (see page 129) is recognized the type specimens may be segregated, in which case they are examined only in critical investigations and thus escape the wear incident to the routine handling in casual consultation. Furthermore, in a large herbarium, it saves the monographer much time and effort to have the types all in one place. In the type collection of the Grass Herbarium of the United States National Herbarium are segregated the designated types, the sheets chosen as types when not designated, fragments of types obtained from other herbaria, photographs of types, duplicate types, and certain historic specimens that are related in some way to the types or throw some important light on the identity of the type. There is also a card index to the types. Thus a botanist, when revising a genus of grasses, has at hand all the available types for consultation.

At the Grass Herbarium it has been found advantageous to bring together a " working collection." In this collection is a representative specimen of each species of grass found in the United States. This herbarium is used for quick comparison in routine identification. In critical cases the main collection must be consulted.

In the Grass Herbarium a plan has been adopted which, like the working collection just mentioned, may not be practicable in a large general collection. According to this plan, keys have been prepared to all the larger genera of the grasses of the United States. Of these keys there are three copies, one set being for office consultation, one being distributed in the working collection, and one in the main herbarium. The office set serves as a place of record for

alterations and hence is in constant flux. As fast as genera are revised in publications, the species are arranged according to the sequence adopted in the revision and an alphabetic index is appended to the key. As mentioned in a preceding paragraph, the systematic sequence is scarcely practicable when the distribution of additional specimens is done by those not familiar with the sequence used.

Each herbarium has its regulations regarding the annotation of specimens. The mounted sheets are usually incorporated in the collection with the original labels which they bore when received, although these labels sometimes give an incorrect name or no name at all. As the specimens are studied it not infrequently becomes necessary to change the names upon the labels or to supply names when these are lacking. A wise regulation, enforced in many herbaria, is that the original label shall not be altered, and that all annotations shall be made upon the sheet itself or upon a piece of paper that is afterward attached to the sheet. An exception which is sometimes made is that the name of the plant may be added to the original label when the specimen was received unnamed. It is a bad practice to scratch the name upon the label and write a correction. On the other hand, annotations should be made only by competent authorized persons, and it is strongly advised that such annotations be initialed and dated by the person making them. It is important to know the author of notes and corrections. Old historic sheets in many of our herbaria bear annotations the importance of which depends upon the identity of the botanist making them. The annotation can often be identified by the handwriting, and some of the large herbaria keep for reference samples of the handwriting of those who are known to have studied the specimens. Type specimens can often be determined by the notes and drawings left upon the sheet by the author of a new species, showing that he studied a particular specimen.

When visiting an herbarium to do critical work upon a group of plants, a botanist usually wishes to make records,

for future study and comparison, of type specimens and other important sheets. These records may be in the form of notes in a book or upon cards. Specimens from the botanist's own herbarium may be brought for comparison; tracings may be made with tracing paper, or drawings may be made of those parts that show distinguishing characters. A satisfactory method is to photograph the sheet. If many photographs are to be taken it may be worth while to use small plates or films and later enlarge them to natural size. If the specimen is of ample size and the curator is willing, a fragment, such as a flower or a portion of a leaf, may be detached and preserved in an envelope. Fragments from types should be given only to specialists, for deposit in an accredited herbarium. Type specimens may be borrowed for study, but the danger of loss in transit discourages this practice. The curators of herbaria will usually supply fragments from type specimens to accredited specialists when this can be done without lessening the usefulness of the specimen. The curators of European herbaria are very helpful to American botanists and are greatly aiding taxonomic science by their ready response to requests of this kind. It happens that a large proportion of the types of the species described from North and South America during the early days of botanical exploration were deposited in European herbaria. In any piece of taxonomic work, the historic phase requires an investigation of these early types. The distance is so great that it is impracticable for American botanists to visit Europe to examine the type specimens except at rather long intervals, and they must therefore depend to a considerable degree upon their European correspondents for aid. The European botanists are only slightly dependent upon American botanists in this respect, because few types of Old World plants are in this country, and European botanists are seldom concerned with American types except when revising groups for the whole world.

Anyone who wishes to build up an herbarium or who becomes curator of a local herbarium will find it to his ad-

vantage to visit one or more of the large herbaria, in any of which he will be given information and advice and an oportunity to study the system and arrangement. At present, the Gray Herbarium of Harvard University, at Cambridge, Massachusetts, is probably the best arranged of our larger herbaria. The collections have been placed in roomy and convenient quarters. The other large collections in this country, except those at the Field Museum, are cramped for want of sufficient space.

The Library

Taxonomic work is based primarily upon a study of plants in the field or in the herbarium, but, as in all scientific investigations, the recorded observations should be consulted, that the work may be coördinated with what has been done by others. During the preparation of a manuscript for publication, many historical data should be incorporated, in order that the account may be harmonious and complete. For these reasons the library is an important part of the scientific equipment.

A worker at one of our centers of research will have access to a large library, but no library is complete. The student usually learns the use of a general library during his preliminary studies, but he must learn also how to use a special library. Where there is a department of botany, developed as a part of a general educational institution, such as a university or an academy of science, the books especially devoted to botany are usually segregated in that department; and if there is an herbarium of sufficient size to support serious taxonomic work, the books on systematic botany are usually deposited in or near the herbarium.

Much of the botanical literature to be consulted, however, will be found in general botanical works or periodicals, or even in works devoted to general science. These books will be found in the main library. In taxonomic work,

books are used in two chief ways. They are consulted, in the first place, to obtain statements of fact bearing upon the investigation as it progresses. Such statements include the descriptions studied and compared in order to establish the identity of plants. In the second place, books are used to furnish the historical data incorporated in or appended to all well-ordered publications.

The actual use of botanical literature in connection with the preparation of definite articles, such as revisions and monographs, will be discussed in another place (see Chapters IX and X). Attention is here called to a few details connected with library methods. The taxonomist deals largely with technical descriptions and figures or plates of plants. He will have at hand most of the manuals, floras and other descriptive works; but he will need to consult many articles or isolated descriptions scattered through general works or scientific serials that cannot be conveniently kept near at hand for consultation even when in the possession of the library. If the part needed constitutes a separate volume of a large work, the particular volume may be withdrawn from the library. It is often possible to obtain from the authors themselves, or from book dealers, separates of articles wanted. If these methods fail, it is recommended that the articles be copied or photographed, especially if the works are not in the possession of the library of the institution at which the worker is situated. Librarians will usually furnish manuscript copies or photographs of articles on request, if the expense is borne by the recipient. Typewritten copies are satisfactory if carefully verified, but photographs are to be preferred as they eliminate the possibility of error. To avoid the expense of numerous large photographic plates, one may make small negatives and subsequently enlarge them; or, if one wishes to take the trouble, the small prints may be read with a reading glass. Photostat reproductions are very satisfactory where the machine is available. Plates may be copied photographically in the same way. Tracings on translucent paper will

also serve a useful purpose if photographs can not be made. The methods here outlined apply especially to paragraphs and short articles. The reproduction of long articles or entire books is attempted only in cases where these are very rare, or where the need is evident and pressing.

CHAPTER IX

THE PREPARATION OF A FLORA OR MANUAL

A preceding chapter was devoted to remarks on the preparation of a local flora. The student's attention may now be turned to similar remarks on the constructive work necessary in the preparation of the flora of a large area. Advanced taxonomic work involving orginal research may take the form of the flora of a region or the revision of a taxonomic group. This chapter will be devoted to work falling within the former category. In preparing a local flora, as outlined previously, the student is chiefly interested in research concerning the distribution of plants in a local area of a comparatively well-known general region, and, in a broad way, he accepts the species as recorded in a general flora. In such a work there would be no original taxonomic investigations or these would be of minor importance.

The author of a general flora, such as is now to be discussed, records original research by bringing together scattered information, by describing neglected characters, such as seeds or underground parts, or by introducing new methods of treatment or new systems of classification if his investigations warrant this. His critical study of groups may make it necessary to describe new species or to re-establish discarded ones.

A work of this kind may be only an account of a single family in a given area, such as the present author's " Grasses of British Guiana";[1] it may be a book, such as Gray's " Manual of Botany," a flora of the northeastern United States; or it may be an elaborate work in many volumes, such as Martius' " Flora Brasiliensis." The more elaborate the work and the wider the area it covers, the more it

[1] Contr. U. S. Nat. Herb. **22** : 439–515. 1922.

tends to include material belonging strictly to the second category, the revision of taxonomic groups. A complete union of the two categories will be found in the " Pflanzenreich " (Plant-kingdom) when this work is completed, for here it is proposed to describe all the plants of the whole world.

Preparing the List of Species

In order to illustrate the methods used in preparing a flora, let us suppose that a student wishes to write an account of the flowering plants of Costa Rica. A flora of this sort is frequently a result of the visit of the investigator to the country whose plants are described, and his own collections may form the basis of the work.

One can not prescribe the exact sequence in which the various parts of the work should be undertaken, and it is not essential that the steps should be taken in the sequence here described. The first step in the project is to prepare a list of all the plants known to belong to the region. For this purpose the investigator catalogs his own plants and those of the herbarium at which he is working, for example, the United States National Herbarium.

A convenient method of preparing this list is to put it in the form of a card catalog, the cards preferably being rather large, say about 4 by 6 inches, one species to each card. This list will be the basis of the whole work.

An attempt is now made to complete the list by adding species (*a*) from published records and (*b*) from specimens in other herbaria. Certain practical difficulties are encountered here. First, the published records must be verified, for one should not accept without question all the species recorded for the region. If the additional species are adequately described, one may identify them from the descriptions, but often they are insufficiently described or only listed. Of course, some of these species will be accounted for through synonymy; that is, species listed under

additional names may prove to be the same as some of those already included in the list.

The additional names taken from lists may be verified by examining the specimens upon which the names are based. This may be done by visiting the herbaria where the specimens are deposited, or the specimens may be borrowed for examination. If these methods are impracticable, one may resort to correspondence and ask the curators of the herbaria in question to examine specimens and give opinions as to their identity.

It is not always easy to locate these specimens, because the authors of the books consulted have not in all cases indicated the herbaria in which the specimens may be found. (For a further discussion of this, see page 75.)

In the case under consideration, the most important work to consult for additions to the list of species is the "Biologia." [1] This is a list of plants reported from Mexico and Central America, including Costa Rica. At the Museum in San José is an herbarium of Costa Rican plants. The most important plants are a series collected by Pittier and Tonduz, duplicates of which have been widely distributed in European herbaria, many being in the United States National Herbarium. The student preparing a flora of Costa Rica should attempt to take advantage of this collection by direct examination or through correspondence.

This knowledge concerning books to be consulted is normally obtained through the student's accumulating experience in library consultation. If he has not had this experience he must make a special effort to become acquainted with the works dealing with the region. Probably the easiest way to do this is to consult the library at the institution where he is doing his work. The floras will be found in the botanical section, classified geographically.

[1] Godman and Salvin, Biologia Centrali Americana. Botany, in 5 volumes, by Hemsley, 1879 to 1888.

From the works dealing, in this case, with Central America, he will find references to others and thus will soon obtain the information needed.

The information on the herbaria of the country concerned will usually be obtained through inquiry. By correspondence and consultation with experienced taxonomists, the student will become acquainted with the herbaria and with botanists of the country — in this case Costa Rica. Dörfler's " Addressbuch " (see page 103) gives the addresses of the botanists of each country and also the names and locations of the more important botanical institutions with the responsible head of each. Dörfler is somewhat out-of-date, but a letter to the director of an institution will usually put one in touch with the official sought. By following these leads one will learn of the existence of the herbarium at San José and can get in touch with Costa Rican botanists.

The Taxonomic Study

Having prepared a list of the species, one may enter upon the critical study of them. The genera of each family are taken up one by one, and their limitations considered; and the species are carefully worked out as to the identity and valid name. Most of the constructive work is done at this stage. The methods used depend upon the form of the proposed publication, which, subject to modification, should be decided upon at the beginning of the project. The form may be that of a mere list of species, which scarcely ranks as a flora. If such a list is provided with keys to families, to genera, and to species, it may be a useful work for purposes of identification, more especially if there are adequate annotations, as described in the chapter on local floras. We may suppose that our Flora of Costa Rica is to be a descriptive work in which the families, genera, and species will be briefly but adequately described; that there are to be keys to the three categories of groups; that there is to be

sufficient synonymy to coördinate the work with the more important floras of adjacent regions; and that there are to be critical notes to record observations made during the investigation.

The notes and observations may be placed on the cards along with all the material that is finally to be incorporated in the flora.

The actual taxonomic work is the most important part of the preparation of the flora. The species are to be correctly identified, and the limits of the species and their relationships are to be determined. The descriptions must be accurate, and must be drawn up from the plants themselves, not copied from other descriptions. Copying descriptions has been too common a practice, resulting in the perpetuation of errors. Finally, the synonymy must be traced.

The author of a flora should form his own judgment as to the limits of genera and species. After determining the type species of a genus (see page 129), he decides what other species should be grouped around this type to form the genus as accepted in the flora. This may require a careful study of the original description of the genus, to determine the distinguishing characters. He may find, on reviewing the history of a genus, that divers species have been added to or separated from the original group, and that the generic concept has changed correspondingly. Occasionally he will find that this evolution in concept has gone so far that none of the original species are contained in the genus as now commonly accepted. On the type basis, the generic concept must include the type species, and the student must make the changes necessary to bring this about. In his review of generic histories he will find that errors have appeared at certain points, that frequently those errors have been copied by others and accepted as fact on the weight of authority, just as in the old-fashioned copy book the pupil tended to copy each line from the preceding one

instead of from the original and the work became worse and worse as it proceeded.[1]

It would be well to include generic synonyms in so far as they affect the native species concerned in the work. Especial attention should be given to synonyms found in works dealing with Central America and to generic names based upon Central American species. These synonyms should not be recorded on the authority of others, but should be investigated by the student. To do this it is usually necessary to consult the original publication. If, in a particular case, the publication is not accessible, the student should, in recording the synonym, state the authority upon which the assignment is made and any other relevant facts. The inclusion of numerous synonyms and bibliographic references, copied from the works of others, gives a false impression of erudition.

The tendency of the usual pedagogic training is to impress the student with reverence for authority. Respect should be accorded where respect is due, but nevertheless the student should approach his taxonomic problems with an open mind. He will do well to question authority, to the extent of proving statements so far as practicable. He may give due weight to the taxonomic opinions or judgments of generally accepted authorities but should not hesitate to investigate statements of fact or to reject opinions when there seems to be sufficient reason for so doing.

While a worker should maintain a critical attitude toward the work of others, verifying everything as far as possible, he should be even more critical of his own work. An inexperienced worker is likely to feel a certainty and confidence in his conclusions, which may lead him to accept

[1] Raf. Amer. Mo. Mag. **2** : 174. 1818. In a review of Pursh's "Flora Americae Septentrionalis," Rafinesque says concerning errors, ". . . it is sometimes very difficult to perceive or detect them; some of them are copied from authors of some respectability, which renders them still more dangerous, as botanists of a common stamp are easily led to believe that what is adopted by an eminent author cannot be erroneous. Errors are therefore followed by the crowd of copyists and compilers, without exercising any criticism."

them without verification. If one finds something very remarkable, supposedly overlooked or misunderstood heretofore, it is always safest to review the work leading up to the discovery and verify every step from the beginning. Some "remarkable new genera" have been described because a plant had been referred to the wrong family, and "remarkable species" have been referred to the wrong genus.

What has been said of genera applies also to the study of the species under each genus. Here, however, the student forms his opinions of the limits and characteristics of species by the study of individual specimens. As in the case of the genera, it is necessary to start with a correct concept of each species by consulting the original description. The original descriptions of some of the species, as written by Linnaeus and the earlier authors, may be too meager to give a correct concept. These earlier descriptions may be supplemented by later ones. Attention should be given to the type locality, the country or location from which the type was obtained. One may well question the name of a species from the mountains of Costa Rica, for example, if the type came from Australia. Wherever possible, the student should examine the type specimens. This assumes particular importance if evidence has come to light which casts suspicion on the identity of the Costa Rican specimens. Since it is not practicable to consult all the type specimens, it is necessary to use all other available evidence bearing on cases in which the type is not accessible. Much can be gained by a careful reading of descriptions and annotations by competent authorities, and by a study of the range of the species and of specimens from different parts of the range, especially if the range is extensive.

Botanists do well to consult their colleagues when gathering information of this sort; and the student is advised to correspond with those botanists, both in this country and abroad, who are likely to possess the information he seeks or who have access to the library or herbarium where the

data can be obtained. There is, on the part of some botanists, a hesitancy to ask freely for information because thereby they may expose to rivals their plans or their prepared but unpublished data. This seems to be especially true when new species are involved. Unfortunately, now and then one finds a colleague who will take advantage of knowledge gained in this way; but most botanists are honorable, and such cases should be looked upon as very exceptional. It is advisable to take this small risk rather than to forego an opportunity to obtain information necessary to round out a piece of work. New species, in themselves, are of minor importance. The risk of their being " stolen " is slight, and even if they are stolen one's work is not thus seriously injured. No one can steal from an author the really valuable part of his scientific work, which is the building up of a carefully prepared article on descriptive taxonomy. From this viewpoint it is clear that he should make every effort to present a complete account of the project in hand based, so far as possible, upon original investigation.

Sometimes the author is so fortunate as to be able to visit herbaria in this country and in Europe in order to consult the type specimens of the species he is studying. In most cases, however, he must depend on correspondence. It is not necessary that the author of a flora should see all the types of the included species. Some species can be definitely identified from the original description, or from illustrations; others can be definitely traced through their taxonomic history. But many cases will arise in which the author can not reach a definite decision by these means. Sometimes he finds two allied species going under the same name. To which of these does the name apply? Not infrequently, under such circumstances, the wrong species has been described as new. An excellent detailed description, of later date than the original, may definitely apply to one of the species, but through an error, this may not be the original species under this name. Thus are botanists mis-

led. If the type of the species can not be consulted, much help can be obtained by asking a botanist, at the institution where the type is deposited, to examine the specimen. If there is some definite, easily determined character by which the two species under consideration can be distinguished, the colleague may be asked to examine the type and report on this point, for instance, whether the leaves are glabrous or pubescent. If the differences consist in a combination of less readily described characters, it is well to send a specimen of each species for comparison. Some of the large herbaria will prepare photographs on payment of the necessary expense.

In seeking type specimens the student is confronted with an important problem, that of locating the types. On this point, only general statements can be made; the location of the types is in itself a piece of research work. In some cases they can not be located. They may have been destroyed, as were some of those of Lagasca, or the species may have been described from living specimens and no type saved. Sometimes it is impossible to connect the original description with a definite specimen. This is true of many of the European species described by Linnaeus, where the description applied to a generally recognized concept and was not based upon a specimen. In other cases, the types are probably in existence but their location is not known. Many early specimens were undated and so inadequately labeled that one can not decide which specimen is the type. The original herbarium containing the types of an author may have been sold or distributed, sometimes broken up and the parts consigned to different places, the history of the transactions being lost wholly or in part.

The great majority of the types can be definitely located, however. In general, the types are to be found in the institution with which the author was connected when he wrote his descriptions. In many cases the book itself will state where the specimens described are to be found. The biographies of authors will usually supply informa-

tion.[1] De Candolle has given the location of a large number of important collections. Lasegue gives an account of the collections incorporated in the great Delessert Herbarium in Geneva at the time his work was prepared. An account of the collections in the herbarium of the British Museum of Natural History has been published, and from time to time there have appeared accounts of the collections at the Kew Herbarium in London, one of the largest collections of plants in the world. Many valuable data can be obtained through direct correspondence with the heads of herbaria.[2] The location of types is one of the phases of taxonomic work in which, as in the knowledge of books, the information is derived to a considerable extent from experience.

Form of Presentation

It is understood, of course, that there is no definite form of presentation that has been approved by botanists. Much depends upon the character of the article and the necessity for economy of space. It is desirable, however, to give thought at the beginning to the plan of the work and then to conform to this throughout. The student should consult works of a similar nature and compare the arrangements and styles.

If cards have been used, it is advisable to continue with them until one is ready to prepare the first draft of the manuscript. The names of the families and genera are interpolated and the descriptions of groups written on separate cards, as are also the range, habitat, and other data referring to the species, and the citation of specimens. All statements that are not directly connected are written on separate cards, so that interpolations can be made without causing confusion or necessitating rewriting.

When the data have been assembled, the author is ready to prepare the first draft of the manuscript. He should now decide upon the exact form, the sequence of

[1] See sources of information, page 101.

[2] See notes on herbaria, page 194.

statements, the paragraphing, the punctuation and the indentation.

For example, the following suggestions may serve as a basis upon which to formulate a plan.

The names of the families and genera are usually centered and are often numbered, the families consecutively throughout the article, the genera consecutively for each family. The numbers are employed chiefly to aid in correlating the names with the keys. The generic names are followed by the authority. Following the name of the family is the description of that family in a single paragraph, with remarks in a second paragraph. Then follows the key to the genera of that family. The treatment of the genera agrees in arrangement with that of the family, but in addition synonymy is given when desirable. The species are keyed under the genus.

The species name may also be centered but usually, to economize space, is made a side head. It is probable that the author will have decided to give bibliographic citations for the species and synonyms, in which case the citation follows the name, the synonyms appearing below. There is considerable difference of method among authors in the placing of synonyms. Some place them immediately after the name at the head of the paragraph; others place them after the description and before the citation of specimens. There will be a paragraph for the description and one or more paragraphs for the other items, according to the taste of the author. He will probably include range, habitat and citations of specimens.

The descriptions vary according to the character of the publication. In the more elaborate works, such as the "Flora Brasiliensis," mentioned above, the descriptions will be complete, that is, the different organs will be described in detail. Even in detached descriptions, the author should be concise and omit non-essentials. Furthermore, generic characters should not be repeated in the descriptions of the species. In a less elaborate work, such as a manual for students, where the primary consideration is the identification of the species rather than a complete taxonomic record, the descriptions are briefer and differences are emphasized. In the complete descriptions given in more elaborate publications, the organs are described, in the account of each species, in the same sequence and in somewhat the same detail. In the manual style, the salient

characters are given but the amount of descriptive detail depends upon the importance of these characters in distinguishing the species. The characters chosen for emphasis will differ even in different groups of the same genus. Some authors add emphasis or attract attention to important characters by italicizing certain phrases.

A simpler style of description may be used in what may be called a descriptive list. The author of the present work has adopted this style in his account of the "Grasses of British Guiana" cited previously (page 69). The descriptions here are very brief, being confined to habit and a few of the more prominent characters, the distinguishing characters having been given in the key. Unless the region selected is well known, a careful study of the flora almost invariably results in the discovery of undescribed species. The technique in regard to the description of new species will be discussed in a subsequent chapter. It is necessary to investigate carefully the literature of the subject before deciding that the supposed new species are actually undescribed. After having examined the floras dealing with the region and the revisions of groups including this area, one must search for isolated descriptions that may have been overlooked by previous authors or may have been described after publication of the floras and revisions examined. It is well to examine the "Index Kewensis," including the supplements, for recent species described from the region under consideration, or from neighboring regions, in the present case, from Costa Rica, or any of the Central American countries, Panama, or even from southern Mexico or the northern part of South America. If the supposed new species comes from the lowlands of Costa Rica, one should examine a wider range, including the West Indies, than if it comes from the mountains. In addition to the "Index Kewensis," one should examine abstracting journals, such as Just's *Jahresbericht*, the *Botanische Centralblatt* and *Botanical Abstracts*. The works mentioned will give references to the place of publication of species that appear to

require investigation. One must then go through this literature and compare the descriptions. Most of the species can be excluded at once on some salient character, leaving only a few to be carefully examined.

An author should make every effort to avoid describing, as new, species that have already been described. Redescriptions of species have been published, and this has given rise to much of the extensive synonymy with which botanical literature is burdened. These remarks do not apply to those descriptions of new species which are based upon differences of taxonomic opinion, but rather to those which are published merely because the author lacks library facilities or has taken insufficient pains. Rather than make the effort to examine the old descriptions carefully, he may prefer to " take a chance " on his new species, hoping that some of them, at least, will prove to be valid.

Even with reasonable care, an author may redescribe species under the impression that they are new. The earlier descriptions may have been published in obscure or ephemeral journals, or they may have been incorrect or misleading. Again, duplication may be unavoidable because there has not been time for the first description to become fully accessible to the botanical public. When a name is published, an indefinite period elapses before the publication reaches the hands of the botanists interested, this period being days, weeks, or even months, depending upon many circumstances. It may, therefore, happen that a species is redescribed as new because the first description was not available to the author of the second. The great amount of time that is sometimes consumed in putting an article through the press increases the chance of duplication. The World War cut off communication between the enemy countries for a considerable period, and duplication of effort was inevitable.

When practicable, it is advisable to illustrate a flora with cuts of at least some of the species, especially the new ones. The subject of illustrations will be discussed in a later chapter.

Usually there are certain supplementary parts to be added to the main body of the manuscript. These are likely to include at least a preface and an introduction. The latter may cover a wide range of subjects, such as the history of botanical exploration, a discussion of the climate, physiography and ecology of the region, and a discussion of the origin of the flora. These subjects will not be followed further here, as they do not directly concern descriptive taxonomy. For the sake of those whose work it is to catalog or record new names, it is well to give a list of these at the end of the article.

The first draft of the manuscript is now to be subjected to careful botanical and editorial examination. It is recommended that the manuscript be triple-spaced so that corrections and interlineations can be made without introducing too much confusion.

One inexperienced in seeing publications through the press may have a general idea that poorly prepared manuscript can be sent to the printing office and come out in good shape, uniform in style. If such manuscript appears in good form it is because someone else has done the work that the author neglected to do. Editing one's own manuscript is drudgery, but it is drudgery that is well worth while, aside from being a moral obligation. No one else can know so well as the author just what he means. If want of punctuation or careless wording leaves a sentence ambiguous, the editor " corrects " it, but, as he has not the author's knowledge, the chances are that the meaning is changed. Accuracy in scientific publication should be recognized as a serious responsibility, not to be shirked. Only the author himself can adequately edit his manuscript. He should, therefore, go over it repeatedly, bringing like parts into uniformity, in paragraphing, capitalization, punctuation and italicizing. Editorial hints will be given in a subsequent chapter.

Finally, the manuscript is copied for presentation to the editor, publisher or printer. It is assumed that the biblio-

graphic citations have been verified in the manuscript, by comparison with the cards. It is well to verify these again, by reference to the original books, and also to verify the cited specimens on the galley proof, by reference to the specimens. Errors creep in so easily that every effort should be made to eliminate them. The index is made from the page proofs. (See page 188 for remarks on indexing.)

CHAPTER X

THE PREPARATION OF A REVISION OF A TAXONOMIC GROUP

A revision is a record of a taxonomic investigation; a monograph is a complete statement of our knowledge of a group, including, besides taxonomy, such subjects as physiology, anatomy, phylogeny and economic uses. The general principles of revisional work may be illustrated as applied to the revision of a genus. The work includes two distinct but interlocking phases, the taxonomic investigation and the preparation of the record. The necessary facilities for taxonomic work in general, a large herbarium and a fairly complete library, can be found only at large botanical institutions, in this country only at the National Herbarium, the New York Botanical Garden, the Gray Herbarium and the Missouri Botanical Garden. Nevertheless, revisions may be prepared at institutions with smaller equipment, if the author is able to supply deficiencies by borrowing specimens and books or by visiting the larger institutions to supplement his preliminary work. Furthermore, the worker at a smaller institution may be able to accumulate facilities for work on a small or local group or one on which the literature is limited or easily obtainable.

In the following discussion, the author finds it convenient to base his remarks upon his own methods and to draw many illustrations from his special field of work, agrostology. In doing this, he does not wish to give the impression that the methods described are the only ones to be recommended or that they are superior to those used by others. Workers develop methods of their own, which differ in detail but must agree in general with those here described.

It may be remarked here that a student is usually led to

attempt the revision of a group by having had his interest in the particular group aroused in some way. He may have been working with the species of a given genus and have found that they were not clearly distinguished, that the keys were not satisfactory, that there appeared to be forms to which the descriptions did not apply — in general, that the group was in confusion and needed critical study. In such a case he already has considerable familiarity with the genus and has an impelling interest in the work, and also may already have taken some of the steps suggested.

It should be understood that it is not essential, and probably will not be practicable, for the student to follow any given set of directions or suggestions or to conduct his investigations in any definite sequence. The remarks here presented for his guidance are only suggestive, and the order of application must be modified to suit circumstances.

Preliminary Studies

Before undertaking the actual revision, the student should familiarize himself with the genus throughout the world and especially in North America. He will examine in detail a representative species, noting the structure of the flower, and compare the results with the description of the genus as given by Engler and Prantl (Pflanzenfamilien), by Bentham and Hooker (Genera Plantarum), and by authors who have previously written upon the genus, or upon the family to which it belongs. He will then note the variation in the structure as shown in a few selected species, and will note the sections accepted or suggested by different authors.

Having gained a theoretical knowledge of the genus, he will then go over the specimens in the herbarium at hand and identify them in a preliminary conventional way, that is, according to the names in common use as shown by our manuals and other descriptive works. Much of the material can be sorted or assigned with confidence, but there will be an accumulation of specimens that require careful

study. These specimens may be laid aside for the present. This preliminary study will suggest the main divisions of the genus, and the keys that have been used will suggest the salient characters by which the species may be distinguished. The student may now to advantage block out a skeleton key or synopsis to the groups of species. The key finally adopted will be the result of many trials and changes, but a preliminary key is a great aid in determining the sequence in which the species are taken up for study.

Preparation of Descriptions

When the student feels sufficiently familiar with the species, he takes up the preparation of formal descriptions. For convenience he will probably follow the sequence of his tentative key. As the first description is a sample or model for those that follow, there must be made at this point a decision as to form. The student will examine the work of others and select a form which suits his taste or which may be modified to suit it. There is no special form which has received definite approval by botanists, but modern descriptions agree in certain basic points. The organs are described in a regular sequence; the statements have a definite grammatical form, such as sentence or participial phrase; and the statements are set off by uniform punctuation.

Descriptive taxonomy has passed through many stages. The earlier descriptions, mostly in Latin, were often brief because the species to be distinguished in each genus were comparatively few. A reference to the classic work, Linnaeus' " Species Plantarum," will show that his descriptions were for the most part from one to three lines long, supplemented by citations from the works of other botanists. As the number of species increased, the descriptions by later authors were lengthened. The descriptions in Hackel's revision of the Andropogoneae and in Stapf's account of the grasses in the " Flora of Tropical Africa " are often more than a page in length.

The generally accepted sequence of statements in a description of flowering plants is from the vegetative to the floral organs, about as follows: general habit, as tree, shrub, herb, or vine, annual or perennial; root, rhizome, or other underground part; stem; leaves; inflorescence; flower; parts of the flower; fruit.

In the actual writing of the description of the species being studied it may be assumed that the student has chosen for convenience a single average specimen as the basis. The description, however, is to be of the species and not merely of the single plant, and hence must include the variations as shown by the specimens at hand. The student might first write a description of the individual specimen and afterwards modify this to correspond to the variations observed in the other specimens. In practice, it will be found more feasible to base each statement on the observed variation. For example, he will say, " Plants annual; stems erect, 40 cm. tall." An examination of the other specimens will show that the height varies from 30 cm. to 60 cm. In fact, one little runt is only 20 cm. tall and another very luxuriant specimen is 100 cm. tall. In recording the height of plants, one must use a certain amount of judgment in order to present to the imagination a fair idea of size. In all species of plants, and in annuals especially, there are dwarfs and giants. These are usually disregarded in a description unless mentioned specially. To be approximately accurate, one might say, " stems usually 30 to 60 cm. tall, sometimes only 20 cm. or the larger ones as much as 80 cm., or rarely even as much as 100 cm. tall." The occurrence of especially large or small specimens may be taken for granted in all plants, and the measurements in the descriptions confined to the usual variation. The same is true of measurements of all the vegetative parts, such as the leaf-blade and the inflorescence. The floral parts are much more constant in size and must be described accordingly. The shape of organs is likely to have more significance than the size. It is a part of the problem set before the student

to form a judgment as to which variations are significant. In separating closely allied species, he must balance differences and resemblances and decide how much variation there is in each species and whether a wide departure from an average constitutes a distinct species.

At an early stage, it is well to determine the kind of characters that can be depended upon to indicate specific differences. These differences may be indicated by the stipules, the relative or actual length or the venation of the blades, or the length, relative and actual, of the petiole. If, in plants that otherwise appear to be of the same species, the pedicels of the flowers vary considerably in length, this character can not be used as diagnostic. One of the crucial points in the work occurs just here. Much of the value of the revision will depend upon the soundness of the student's judgment as to the relative importance of different kinds of characters in determining relationships and differences. The necessity for ample material upon which to base a judgment is now obvious. The significance of variations as indicating species depends much on the coördination of the variations. If organs vary independently, the variation means little; if they vary in groups, that is, simultaneously, or if morphological differences can be coördinated with a difference in range, the variation becomes important taxonomically.

Specimens that appear to break down specific lines should be examined with special care. They may be rare intermediates which do not influence the distinctive characters used in separating two species. Or they may point the way to a further study of the material at hand, to determine whether the two supposed species are really distinct. Sometimes it may be found that the species are distinct but that emphasis has been placed upon the wrong characters. At any rate, these puzzling specimens should not be ignored but should be disposed of and duly recorded in the manuscript.

Correct taxonomic judgment comes partly from experience and partly from intuitive scientific ability. A patient

and painstaking worker may record a large number of data and yet not be able to develop taxonomic judgment. This comes from the ability to distinguish from the mass those facts which are significant.

In giving the limits of measurements concerning the usual size, such as height of plant, length and breadth of leaf-blade, and length of inflorescence, it is best to use round numbers rather than the actual measurements from the specimens themselves. If the length of the leaf-blade in twenty specimens is found to vary from 3.8 cm. to 16.1 cm., the length may be recorded as 5 to 15 cm. In those measurements which exhibit a small ratio of variation, such as the size of the floral parts, the recorded limits of size should agree more closely with the actual measurements. A seed found actually to vary in diameter from 1.8 to 2.1 mm. should be recorded either as 1.8 to 2.1 mm. or as about 2 mm. in diameter. The choice between these methods depends upon conditions. If, after numerous measurements have been taken, the extremes are found to be rather frequent, the first form of statement should be used; if extremes are rare, the second form is sufficiently accurate.

Another method of recording measurements, used by some authors in certain cases, is to give the maximum size, as, for example, " a small tree as much as 6 meters in height," or, " a panicle as much as 14 cm. long." This method is recommended when the minimum size has no significance.

In determining measurements, for example, those of petals, there are two series of cases to be considered, the variation on a single plant, and the variation in a single species. The significance of variation is, of course, amplified when this can be coördinated with other characters.

The practice of the present writer is to record data on the sheets of specimens examined, as they can then be referred to from time to time and specimens directly compared. The data may include drawings or dissections.

It may not be amiss at this point to emphasize the necessity of using specimens with care. Dissections of flowers and other parts should be

preserved in packets on the sheet, for later reference and for the use of others. Parts that require boiling for dissection will keep indefinitely if a drop or two of glycerine is added to the water in which they are boiled. Dissections may be mounted between strips of isinglass, the mount being preserved in a packet.

Thus the student builds up his description, taking the original statement from his average specimen and checking results by examining the others. If the specimens at hand really constitute individuals of a single species and the number of specimens is large enough to give a fair representation of the species, the description should be satisfactory and he will be ready to pass on to another species. It often happens that certain specimens show peculiarities that lead to a more detailed study, as a result of which the specimens may be excluded at least temporarily from the species under investigation. Sometimes these specimens are finally referred to other known species or may prove to be new species; sometimes the ultimate decision is that they are to be included in species from which they were taken, and the description is modified to cover their peculiarities.

It is important to be clear and concise, and to avoid the use of unnecessary words. The best description is one that enables the reader to form a mental picture of the plant. It is well to test the description by comparing this mental picture with the plant itself, to see if important characters have been omitted. A description may be accurate and yet may be so weighted down by unimportant details or variations that the picture is obscured. It is sometimes better (especially in a variable species) to describe the average group and then at the end give ranges of variation — that is, first build up the picture clearly, then supplement with details of variation.

Concerning the technique of a description, it may be said that the form should be consistent, the statements clear, and the technical terms selected with care. The form is a matter of taste or style and may be decided upon after consulting standard descriptive works. A combination of brevity and

clearness and the avoidance of ambiguity require a careful consideration of the arrangement of phrases. Some botanists prefer an elaborate sentence form of statement. Some would separate the main statements with periods and the minor ones with semicolons. Some use hyphens or short dashes between the measurements instead of using the word "to." The main point is to keep the statements regular in sequence and uniform in style, so that descriptions will be readily comparable. It is customary to use the metric system in expressing measurements, though one sometimes finds the English system used in standard works, such as the "Flora of British India." Many authors avoid the use of the decimeter in giving metric measurements, those between one centimeter and one meter being given in centimeters. This is for the practical reason that the abbreviation dm. may be confused by the printer with cm. and the error escape notice in proof-reading. For convenience, the limits of measurements are given, when practicable, in the same units for each organ. A blade is 5 to 15 mm. wide, or 0.5 to 1.5 cm. wide; a plant is 60 to 120 cm. tall, or 0.6 to 1.2 meters tall. This is preferable to 5 mm. to 1.5 cm. or 60 cm. to 1.2 meters. In general, it is advisable to avoid decimal points for the reason mentioned above — the possibility of errors in proof-reading. If decimal points are used with parts of a unit, it is well to place a zero before them.

A few words here as to Latin descriptions. The International Rules of Nomenclature require that the descriptions of new species (or other groups) be in Latin, or at least be accompanied by a diagnosis in Latin. A diagnosis is a brief description including the important characters by which the group may be distinguished. Latin was the language of literature during the Middle Ages, and persisted as the language of botany well into the last century. During this time, it was the only language common to the educated people of all countries. The use of Latin has decreased in later years and does not now hold a dominant position.

It is evident, however, that if the botanist publishing a new species described it only in his native language, the description would not be intelligible to all other botanists. Most botanists have a reading knowledge of English, French, German and Latin. Other languages are known to a few, as foreign languages. But Latin is a supplementary language for workers in all countries, and therefore serves best as a common language for descriptions.

On the other hand, a description is more likely to be clear and accurate if written in a language with which the author is perfectly familiar, and few people become as familiar with a second language as with the mother tongue. Taking everything into consideration, science is best served when the original description is written in the author's mother tongue and to it is appended a diagnosis in Latin. The necessity for a Latin diagnosis is especially evident when the description is written in a language unfamiliar to most botanists, such as Japanese or Russian.

Following the description may be a paragraph giving habit and range. After this will come the detailed distribution by states and countries, with the citation of specimens, if this has been included in the plan. Aside from the advantage of the record in citing specimens, there is the aid which the student receives in checking his descriptions. Each specimen must be definitely passed upon and assigned to its species. Probably the description will be altered here and there to accord with the additional facts. Usually a few specimens will be set aside as probably belonging to a different species. Before the revision is completed, the specimens thus set aside from various species must be disposed of in some way. They may belong to distinct undescribed species, or they may represent subspecies, varieties, or forms that can be recognized, or they may be aberrant forms that are referred to described species. If there is but one aberrant specimen among those examined in connection with a given species, one may hesitate to con-

sider it as representing a distinct species. Sometimes other specimens are found among those referred to other species, or among the undetermined specimens that always accumulate in an herbarium. If these specimens show distinctive characters in common, one is justified in describing them as a new species. A consideration of such questions constitutes a part of constructive taxonomic work.

There are many methods of citing specimens, and the student should examine the work of others and then decide upon his own plan. If space permits, it is well to group the specimens by states. To save space, the matter may be run solid instead of in paragraphs by states and countries. Some authors prefer to give the citation of each specimen in more detail, including the date, habitat, and even the initials of the collector. All these things are matters of choice with the author, but when he has made a decision he should try to be consistent in a given article.

During the preparation of an article, the author is obliged to consider many matters concerning form which are not provided for in the general plan. In order to maintain consistency, it is well to make a list of such decisions in order to refer to them when the same case occurs again.

It is often desirable to include notes of various sorts that find no definite place in the formal description or in the distribution. These notes are of special value to the user of a revision and give opportunity for the author to record facts and opinions that could not otherwise be set down.

In the notes, one can point out the more prominent differences separating the species from its nearest relatives and can discuss unusual specimens or vagaries in range. One should be careful, however, not to try to " make out a case " by unduly emphasizing small differences in order to justify a new species or to justify the retention as species of two closely allied forms. One should tell the truth and record the facts as one finds them.

New Species

Among the descriptions there will probably be some of new species. These are made in the same form as the others, with the addition of a paragraph on the type. The type concept, though modern, is now so generally accepted that it is assumed the student will assign types for his new species. (For a discussion of types, see page 139.) The type specimen may be indicated in many ways, the simplest being to write the word type after this specimen in the list of specimens. A definite form of type paragraph has been adopted in the Contributions from the U. S. National Herbarium, and is as follows:

Type in the U. S. National Herbarium, no. 1,038,505, collected in rich soil along edge of forest, about 3 miles southwest of Bartica, British Guiana, December 10, 1919, by A. S. Hitchcock (no. 17,194).[1]

It is important to state in what herbarium the type is located. If the plants with which the student is working are in a public institution, the types will naturally remain there. If the type of a new species happens to be in a private herbarium or even in a small public herbarium, it is advisable to make arrangements by which it can be donated to one of the large public herbaria. There it will be more accessible to botanists and will have a safer and more permanent place of deposit than if it were in a private herbarium.

When the descriptions of the species have been completed, the key to species should be prepared. Keys are so important that a separate chapter has been devoted to that subject (see page 104). The key to the species of the genus under consideration has probably been partially constructed during the preceding study and it now remains to complete this, put it in correct form and test its accuracy. It is well to carry several specimens through the completed key to

[1] The sheets of specimens in the U. S. National Herbarium are all numbered, and the sheet number of the above type is recorded in the first line of the paragraph. The number in parenthesis is the collector's field number.

see if it "works." In selecting characters to distinguish species in the key, care must be taken to see that the key characters agree with those given in the descriptions for the corresponding species. If two species are separated in the key on the basis of the length of the petals, one species having these organs 4 mm. long, and the other 6 mm., it is unfortunate if a reference to the description shows the petals in the first species to be 3 to 5 mm. and in the other 5 to 7 mm. One might change the key to read petals averaging 4 mm. and 6 mm. respectively. But even so, it is advisable to add a secondary distinguishing character.

When revising genera with formally described sections or other subdivisions, one may make a key to the sections and separate keys for each section, or one may combine all in a single key.

The Genus and Its Synonymy

Finally, the author supplies the description of the genus and such introductory matter as is called for by his plan.

The description of the genus follows, in the main, the same lines as that of the species, already referred to, except that the sequence of organs is somewhat different. In our present system of classification, the generic characters are mainly those of the floral organs. Consequently, the description usually begins with the flower or some of its parts, the exact sequence depending upon the family of plants to which the genus belongs. Ordinarily the sequence is, calyx, corolla, stamens, pistils, fruit. In such families as Brassicaceae (Cruciferae) and Apiaceae (Umbelliferae) the description might start with the fruit, in Asteraceae (Compositae in part) with the head. In Poaceae (Gramineae) it starts with the spikelet. Later are given the inflorescence, the fruit, the foliage, and the habit and duration in so far as the characters are generic, that is, common to all the species.

The description does not include characters common to the groups of a higher order. In a genus of the Monocotyledoneae it would not be necessary to state that the vascular

bundles of the stem were distributed through the pith (as is usual in that group), nor in a genus of Fabaceae (Leguminosae in part) that the pistil was simple. One assumes the usual structure of the family and higher groups and mentions only those characters that are called generic. On the other hand, the description is not confined to those characters which distinguish the genus from others. In the main, a generic description gives the characters common to the species but does not repeat the obvious characters common to the family and to higher groups. Immediately following the technical description of the genus may be placed a paragraph on the general habit, whether annual or perennial, whether bearing rhizomes or not, and other points of this sort not included in the preceding description; then a statement as to the number of species in the genus throughout the world, and the geographic and altitudinal distribution. In estimating the total number of species, an attempt should be made to obtain the facts from original sources, that is, by consulting recent floras covering the various areas, and not by borrowing a statement from the general works on genera, such as those of Engler and Prantl or Bentham and Hooker.

A very important part of the work of a revision is the synonymy, the tracing out of the taxonomic and nomenclatural history of the genus and species. The citations of the valid species and of synonyms should be verified, as far as possible, from the original sources. The synonyms are recorded in chronological order, usually immediately following the generic or specific heading. To determine the application of the various names, it is necessary to study the descriptions carefully, and, where possible, to examine specimens mentioned by the author. Of special significance in determining specific names is the type specimen (see page 77), and this should always be examined if accessible. To determine the application of a generic name, one must know upon what species it is based or what is the type species. It is advisable to record the reasons for assigning

each name in the synonymy both of genera and of species. The present author prefers to give the discussion relating to synonymy in the paragraph devoted to each synonym. Some authors give these data in an introductory statement or in an appended paragraph under the individual species. One might discuss also under each synonym the characters by which it was distinguished and why one does not recognize it as valid. As an example of generic synonymy, the following, under *Festuca*, is taken from the author's work on the Genera of Grasses.[1]

Festuca L. Sp. Pl. 73. 1753; Gen. Pl. ed. 5, 33. 1754. Linnaeus describes 11 species. *Festuca ovina* is chosen as the type, as it is the first of the original species that is economic and is described in the flora of Sweden. Most of the original species are still retained in *Festuca* but *F. decumbens* is now placed in *Sieglingia*, *F. fluitans* in *Panicularia* and *F. cristata* in *Koeleria* (*K. phleoides*).

Vulpia Gmel. Fl. Badens. **1**: 8. 1805. One species, *V. myuros*, based on *Festuca myuros* L., is described, and two species of *Festuca* having a single stamen are mentioned in a note. *Festuca myuros* is taken as the type.

Schedonorus Beauv. Ess. Agrost. 99, pl. 19, f. 2. 1812. The first of the 25 species included and the one figured is "*Bromus elatior*" (L.) Koel., based on *Festuca elatior*. The figure shows a floret with a short awn below the minutely bidentate apex, as found in occasional specimens of *F. elatior*, which species is taken as the type.

Dasiola Raf. Neogenyt. 4. 1825. "Type *Festuca monandra*" Ell., renamed *D. elliottea* Raf. This is *F. sciurea* Nutt.

Chloamnia Raf. Neogenyt. 4. 1825. Two species are included, *Festuca tenella* and *F. bromoides*. The first, which is *F. octoflora* Walt., is taken as the type.

Hesperochloa (Piper) Rydb. Bull. Torrey Club **39** : 106. 1912. Based on *Festuca* subgenus *Hesperochloa* Piper, the type and only species of which is *F. confinis* Vasey.

Wasatchia Jones, Contr. West. Bot. **14** : 16. 1912. A single species is included. *W. Kingii* (Watson) Jones, based on *Poa Kingii* Watson, which is the same as *F. confinis* Vasey.

Gnomonia Lunell, Amer. Midl. Nat. **4** : 224. 1915. A new name proposed for *Festuca* L., not *Dodonaeus*, 1551. [The type in this case must be the type of *Festuca* L.]

[1] U. S. Dept. Agr. Bull. **772** : 28. 1920. Genera of Grasses of the United States.

Specific Synonymy

As an example of specific synonymy, the following is selected from the author's "Revision of North American Species of Chaetochloa" (Contr. U. S. Nat. Herb. **22** : 162. 1920):

4. Chaetochloa sulcata (Aubl.) Hitchc.

Panicum sulcatum Aubl. Pl. Guian. **1** : 50. 1775. In this work, the flora of French Guiana, Aublet states that this grows along rivers but gives no definite locality. The type has not been examined. Aublet's short diagnosis "Panicum (sulcatum) latifolium foliis liratis" is taken directly from Plumier's Catalogue,[1] "Milium latifolium foliis liratis," which Aublet cites as a synonym. Aublet further cites *Milium latifolium sulcatum* Plum. mss. 4. t. 105. Lamarck[2] gives a more complete description, citing Plumier's Catalogue and the manuscript plate (105), and *P. sulcatum* Aubl. He states that the plant grows in Martinique where it was observed by Plumier, and that he has seen the specimen in Vaillant's herbarium. Urban[3] states that the species agrees with "Codex Boerh. II. tab. 641," a manuscript work. Urban unites with *Panicum sulcatum* the specimens which in this article are referred to *Chaetochloa palmifolia.*

Panicum paniculiferum Steud. Syn. Pl. Glum. **1** : 54. 1854. "Oaxaca." The type specimen has not been definitely located. Galeotti's no. 5858, from Oaxaca, the only collection cited by Fournier under *Setaria paniculifera*, is in the Paris Herbarium. This specimen, which may be the type of *Panicum paniculiferum*, consists only of the inflorescence and a fragment of the culm; the lower panicle branches are as much as 20 cm. long, and the branchlets are appressed or ascending.

Setaria effusa Fourn. Mex. Pl. **2** : 42. 1886. Several specimens from Vera Cruz and Oaxaca are cited, the first being Bourgeau 2599, from Orizaba. This specimen has spreading branches and branchlets, with less crowded spikelets and rather fewer bristles. Hitchcock's no. 6380 from Orizaba has a like panicle. These represent only an extreme form, connected by intergrades with the less open, more bristly form represented by Galeotti's no. 5858.

Setaria paniculifera Fourn. Mex. Pl. **2** : 42. 1886. Based on *Panicum paniculiferum* Steud.

Chamaeraphis effusa Kuntze, Rev. Gen. Pl. **2** : 770. 1891. Based on *Setaria effusa* Fourn.

[1] Plum. Cat. Pl. Amer. 10. 1703.
[2] Encycl. **4** : 746 bis. 1798.
[3] Repert. Nov. Sp. Fedde **16** : 148. 1919.

Chamaeraphis paniculifera Kuntze, Rev. Gen. Pl. **2** : 770. 1891. Based on *Panicum paniculiferum* Steud.

Chamaeraphis sulcata Kuntze, Rev. Gen. Pl. **2** : 770. 1891. Based on *Panicum sulcatum* Aubl.

Panicum mexicanum Scribn. & Merr. U. S. Dept. Agr. Div. Agrost. Bull. **21** : 40. 1900. Based on *Setaria effusa* Fourn.

Chaetochloa sulcata Hitchc. Contr. U. S. Nat. Herb. **17** : 260. 1913. Based on *Panicum sulcatum* Aubl.

At this point might be inserted a statement concerning any misapplication of the name, as indicated on page 124.

A further discussion of this subject will be found in a later chapter, under Homonyms and Synonyms and under Types.

This search for synonyms is beset with difficulties because they are sometimes buried in obscure places. First, the generally accepted synonyms are tested as each species is studied. As a matter of precaution it is well to note, during the taxonomic study, while referring to the older works, all synonyms that are recorded. These are tested and checked off as the work progresses. Finally there should be a systematic search for the remaining names. The " Index Kewensis " and its supplements will furnish a basis for specific names. All names not already disposed of should be examined to determine the original or type locality. If the student's revision concerns North America, he is interested in all names based upon material coming from that continent. He is also interested in those whose type locality is the northern part of South America, especially if the names have been applied to species from North America.

As the " Index Kewensis " does not catalog varieties, it is necessary to seek these in the original works. The species published since the preparation of the last supplement to the " Index Kewensis " must be found by a patient search through recent literature, especially abstracting journals. At the Grass Herbarium in Washington, there is a card catalog of published genera, species and varieties of grasses. Every effort is made to keep this as nearly up to date as practicable. This catalog is the basis for references to

synonymy for investigators on agrostology at this place, and the data from it are given to anyone asking for them.

Besides assigning synonyms to the recognized species, the student should account for misapplications of names in the more commonly used books. For example, while revising the genus *Panicum*, the author found that the name *Panicum brevifolium* L. was being misapplied in most of the works on tropical American plants. *Panicum brevifolium* L. is a valid Asiatic species, different from the American plant so called, which should bear the name *Panicum trichoides* Swartz.

Some authors cite misapplications of names in the synonymy in the same form as true synonyms. This is confusing and it seems better to refer to misapplications in a different way. For example, Grisebach (Fl. Brit. W. Ind. 552. 1864) uses *Panicum brevifolium* for the species mentioned. If one cites the name in synonymy under *P. trichoides* as *Panicum brevifolium* Griseb. not L., the reader would be led to assume that Grisebach describes *P. brevifolium* as a new species but gives it a name preoccupied. If one wishes to include misapplications in a formal manner in the list of synonyms, it is advisable to indicate clearly that the name is a misapplication and not a true synonym, as:

Panicum brevifolium of authors not of L., or
Panicum brevifolium as described by Griseb. (Fl. Brit. W. Ind. 552. 1864).

Piper (Contr. U. S. Nat. Herb. **11** : 282. 1906) cites such cases in the following manner:

Aconitum nasutum Fisch. err. det. Hook. Fl. Bor. Am. **1** : 26. 1829. (Under *Aconitum columbianum* Nutt.)

The present writer (in Jepson, Fl. Calif. **1** : 147. 1912) has used the following form (under *Melica bulbosa* Geyer):

Melica poaeoides [Nutt. misapplied by] Torr. U. S. Rep. Expl. Miss. Pacif. **4** : 157. 1857.

Probably a better way, where the plan of the work permits, is to mention misapplications in a separate paragraph. In the revision of *Panicum* mentioned above (Hitchc. & Chase, Contr. U. S. Nat. Herb. **15** : 129. 1910), the authors say under *Panicum trichoides* Swartz:

> This species has usually been referred by authors of American floras to *P. brevifolium* L., which is from India and is the same as *P. ovalifolium* Poir. as described by Hooker (Fl. Brit. Ind. **7** : 44. 1896) and a very different species.

In a revision, the description of the genus might be more detailed and there might well be a discussion of the variation in the structure of the organs as shown in different species. One might add a paragraph on the genus as represented by species beyond the limits included in the revision, and might also give a history of the genus, telling how it has been confused, what new character is here presented to differentiate it, and so on.

The introduction and preface deal, for the most part, with subjects outside the scope of descriptive taxonomy but form an important part of the work and the part of most interest to the general reader.

Sources of Information, Bibliographic and Biographic

Certain works are an aid in seeking information on books and periodicals. A few of the more important are here enumerated.

Pritzel, G. A. Thesaurus literaturae botanicae omnium gentium inde a rerum botanicarum initiis ad nostra usque tempora, quindecim millia operum recensens. Ed. Nov., 1872. This gives the author, title and other bibliographic data concerning botanical works published up to about 1870.

Jackson, B. D. Guide to the literature of botany. London, 1881. Especially useful for works before 1880 not in Pritzel's " Thesaurus."

Catalogue of the Library of the Royal Botanic Gardens, Kew. Bull. Misc. Inf. Add. Ser. III. London, 1899.

International catalogue of scientific literature. M. Botany. 1902–1919. Fourteen annual issues covering the years 1901–1914.

Bolton, H. C. A catalogue of scientific and technical periodicals 1665–1895. 1897.

Scudder, S. H. Catalogue of scientific serials of all countries, including the transactions of learned societies in the natural, physical and mathematical sciences, 1833–1876. 1879.

Handbook of learned societies and institutions. America. Published by the Carnegie Institution, Washington, D. C., 1908. A list of learned societies and institutions in North and South America, with notes on publications.

Britton, N. L. A list of state and local floras of the United States and British America. Ann. N. Y. Acad. Sci. **5** : 237–300. 1890. (Contr. Herb. Columb. Coll. **14.**)

Three important works dealing with the date and place of publication of plant names are:

Index Kewensis plantarum phanerogamarum nomina et synonyma omnium generum et specierum a Linnaeo usque ad annum 1885 complectens nomine recepto auctore patria unicuique plantae subjectis. 4 volumes. 1893–1895. Five supplements have been issued.

Pfeiffer, L. Nomenclator botanicus. Nominum ad finem anni 1858 publici juris factorum, classes, ordines, tribus, familias, divisiones, genera, subgenera vel sectiones designatum enumeratio alphabetica. 2 volumes, 4 parts. 1873–74.

Dalla Torre and Harms. Genera siphonogamarum ad systema Englerianum conscripta. 1900–1907. A list, with bibliographic citations, of the names of groups above the species, of phanerogams, systematically arranged, with index.

Among books containing information on biography and the location of collections, may be mentioned the following:

Cattell, J. McK. American men of science. A biographical dictionary. Ed. 3. 1921.

Dörfler, I. Botaniker-Adressbuch. Sammlung von Namen und Adressen der lebenden Botaniker aller Länder, der botanischen Gärten und der die Botanik pflegenden Institute, Gesellschaften und periodischen Publicationen. Ed. 3. Wien, 1909. Gives the names and addresses of botanists and botanical institutions of all countries.

British Museum. The history of the collections contained in the Natural History Departments. Vol. 1. Libraries. Dept. Bot.; Dept. Geol.; Dept. Min. London, 1904.

De Candolle. La phytographie. 1880. There is an English translation.

Lasegue. Musée botanique. Paris, 1845. An account of the collections in the Delessert Herbarium at Geneva, of the important herbaria in Europe, of botanical voyages and expeditions, of the biographies of botanists, and of other related subjects.

Kew. A list of the contributors to the herbarium of the Royal Botanic Gardens, brought down to 31st December, 1899. Bull. Misc. Inf. Jan.-Mar., 1901.

The most recent exposition of the subject, common names of plants, is Olmsted, Coville and Kelsey. Standardized plant names. A catalogue of approved scientific and common names of plants in American commerce. 1923.

CHAPTER XI

KEYS AND SYNOPSES

The student has become familiar with keys in his routine identification of plants, and in the preceding chapters references have been made to keys in discussing the preparation of floras and revisions. Attention will now be called to the mechanical construction of keys and to the function they perform in taxonomy.

A key is an orderly arrangement of a series of contrasting or directly comparable statements, by which groups of the same category may be distinguished and indicated or identified.

A synopsis is a segregation of groups of the same category into successively smaller divisions according to characters common to the members.

A key is primarily a mechanical device by which one may arrive at the name of the ultimate member of the group. A synopsis is primarily a taxonomic summary of characters by which the members are classified. A key is concerned chiefly with quick identification; a synopsis is concerned chiefly with showing relationships. A key is usually placed at the beginning of the group to be classified; a synopsis is usually distributed among the members of the group. However, there are various combinations of keys and synopses and no sharp line may be drawn between them; and there are cases where keys and synopses are used simultaneously. In America there is an increasing tendency toward the use of keys rather than synopses. Keys and synopses are sometimes referred to as analytic keys and synoptic keys.

The simplest kind of a key would be a pair of contrasting statements concerning two groups. For example:

Flowers red..... Species 1
Flowers blue..... Species 2

With a greater number of species, the distinguishing statements may divide the species into groups of the first order, then divide each group into smaller groups of the second order, and so on until the individual species are reached.

In a key, the most prominent characters are selected to distinguish the subdivisions at each successive step; hence the species or other groups that are brought together may not be closely allied, and the sequence is not according to their genetic relationships. As the purpose of a key is primarily to identify groups as certainly and quickly as possible, the characters chosen are those that show the strongest contrast rather than those that show relationships.

If the characters are chosen so as to divide the groups successively along natural lines, the key is said to be a natural or systematic key. If the characters are chosen rather to bring out sharp contrasts without regard to affinities, the key is an artificial one.

From the standpoint of mechanical construction, there are two types of keys in use, the bracket key and the indented key. The bracket key is illustrated by the following:

1. Flowers red..... 2
1. Flowers blue..... 5
2. Leaves simple..... 3
2. Leaves compound..... 4
3. Petals 4..... Species 1
3. Petals 5..... Species 2
4. Leaflets 5..... Species 3
4. Leaflets 9 or 11..... Species 4
5. Flowers sessile..... Species 5
5. Flowers pediceled..... 6
6. Inflorescence a raceme..... Species 6
6. Inflorescence a panicle..... Species 7

The bracket key is the more economical of space, because each line is flush to the left of the page. The same species, keyed out by the indented form, would appear as follows:

Flowers red.
  Leaves simple.
    Petals 4 ..... Species 1
    Petals 5 ..... Species 2
  Leaves compound.
    Leaflets 3 ..... Species 3
    Leaflets 9 to 11 ..... Species 4

Flowers blue.
  Flowers sessile ..... Species 5
  Flowers pediceled.
    Inflorescence a raceme ..... Species 6
    Inflorescence a panicle ..... Species 7

The indented key is more easily followed and makes the relationships of the divisions more readily apparent to the eye.

As a basis for discussion, let us examine an indented key to the species of the section Uniseta of the genus *Aristida* in North America. In this section the lateral awns are minute (less than 1 mm. long) or wanting.

Awn (column) twisted at base .....1. *A. Schiedeana.*
Awn not twisted.
  Plants annual; axils and branchlets beset with a few long hairs; awn flexuous .....2. *A. jorullensis.*
  Plants perennial; axils and branchlets devoid of long hairs; awn curved but not flexuous.
    Awn more or less arcuate but not horizontally bowed; panicle open, the branches long and naked below (shorter in var. *divergens*); lateral awns mostly obsolete ..... 3. *A. ternipes.*
    Awn curved in a semicircular bend, the terminal part horizontal or deflexed; panicle narrow, the short

branches spikelet-bearing from the base or nearly so; lateral awns present, less than 1 mm. long.
Sheaths pilose at throat; first glume 6 mm., the second 8 mm. long.....4. *A. Purpusiana.*
Sheaths glabrous at throat; first glume 12 mm. long, the second a little shorter....5. *A. geminiflora.*

In this example the successive divisions are in pairs. Such keys have been called dichotomous. This pairing of the divisions, or " legs," of a key is for the sake of definiteness. If there are more than two divisions, especially in long keys where the divisions appear on different pages, the user may overlook a third one. If the divisions are uniformly in pairs, one does not look for a third. The ultimate divisions may be in three's without introducing uncertainty, if they all come on the same page. In the example, the successive branches are indicated by indentations, two members of the pair having the same indentation. In long keys one is confronted with certain mechanical difficulties. Successive indentations finally leave insufficient space at the right for the paragraph, and much vacant space is wasted at the left. Some of the long keys in the " North American Flora " illustrate the thinning out of the reading matter. This may be overcome in either of two ways. The key may be brought back flush to the left by a continuation. This is illustrated in the key to the species of *Panicum* subgenus *Dichanthelium* (Contr. U. S. Nat. Herb. **15** : 149. 1910) which occupies seven pages. Another method is to use center heads, preceded by conventional signs, for the earlier branches of the key, relying upon indentation for the latter part.

Even with indentations, it is well, in a long key, to use signs, numbers, or letters to aid in finding corresponding branches. The present writer has used such signs throughout in the key to genera of his " Genera of Grasses " (U. S. Dept. Agr. Bull. **772** : 9–22. 1920). A portion of this follows:

1a. Spikelets all perfect, surrounded by a copious tuft of soft hairs 2
2a. Rachis continuous, the spikelets falling; spikelets of the pair unequally pedicellate 3
3a. Racemes in a narrow spike-like panicle; spikelets awnless . . . . . 128. *Imperata.*
3b. Racemes in a broad fan-shaped panicle; spikelets awned . . . . . 129. *Miscanthus.*
2b. Rachis breaking up into joints at maturity with the spikelets attached; one spikelet sessile, the other pedicellate 4
4a. Spikelets awnless . . . . . 130. *Saccharum.*
4b. Spikelets awned . . . . . 131. *Erianthus.*
1b. Spikelets unlike, the sessile perfect, the pedicellate sterile (sessile spikelet staminate, pedicellate spikelet perfect in *Trachypogon*) 5
5a. Pedicel thickened, appressed to the thickened rachis joint (at least parallel to it) or adnate to it; spikelets awnless, appressed to the joint 6
6a. Rachis joint and pedicel adnate, forming a short flat joint, this sunken in the open side of the globose first glume of the sessile spikelet; sterile spikelet conspicuous . . . . . 140. *Rytilix.*

In the indented key, it is usual to have the two parts of any pair in the divisions commence with the same word in order to aid in coördinating one part with the other. Some authors go so far as to avoid using the same word at the beginning of adjacent pairs of a different order in the series. The use of the same word at the beginning of pairs is scarcely necessary where signs are used to supplement indentation, as in the above key.

The statements in the two members of a pair should be contrasting. The statements are usually in phrase form, as in technical descriptions, and are set off uniformly by punctuation, usually by semicolons. If the character used is definite and easily observed, it may be sufficient and may

stand alone. If it is necessary to use a somewhat indefinite character, one that can not be easily observed in an herbarium specimen, or one that can not be shown in a single specimen (such as flowers and fruit), there should be supplementary characters. The supplementary characters, when paired, should be contrasting, and the phrases should be in the same form and commence with the same word. Sometimes it is advisable to add to one member of a pair a statement which does not contrast with any part of the other member. Such statements are added for purposes of confirmation, although the contrasting characters are not found in all the members of the other division. For instance, in the key to *Aristida* given above, there might have been added to the first member of the first division the non-contrasting supplementary statement, "Plants perennial; grasses of the Mexican table-land." The statement is not contrasting, because the second member contains both annual and perennial plants. Statements of this kind are often set off by periods to distinguish them.

There is a disposition among some authors to arrange the members of each pair in the key so that the one with the smaller number of species or other groups shall come first. This is to make it easier for the user to follow the ramifications. There are reasons for and against such an arrangement. In the example given above under *Aristida*, the "short leg" of the key comes first and the species are numbered in the text to correspond to their sequence in the key. An author is likely to arrange the species in the text according to his opinion of their natural affinities, and it happens that in *Aristida* they are so arranged when the short division is placed first. A dichotomous key with the shorter division placed first throughout will, in most cases, bring the species in a sequence differing markedly from that of the text. The two arrangements can be accommodated to each other by retaining in the key the numbers assigned to each species in the text. In this case the numbers in the key will not be in sequence.

Some authors prefer to have the numbers in sequence in the key and yet to have them agree with the arrangement in the text. This can be brought about, at least approximately, by abandoning the method of placing the short division first. It may be necessary to choose the key characters somewhat differently. The keys in the "North American Flora," in Small's "Flora of the Southeastern States," and many other works of this kind are arranged in the manner just described. Keys may be found in which the shorter divisions are placed first on purely artificial characters, and in which the numbers of the species are in sequence, the text being arranged accordingly. By this method the species will not be arranged according to natural affinities. These are all matters of choice with the author and no definite method has received universal approval.

In constructing artificial keys, one may solve difficulties occasionally by placing the same ultimate group in each branch of a given subdivision. In looking for a character to separate a series of species into two divisions, it may be found that a certain character sharply divides the series except in the case of one species, no other character making so sharp a separation. One may then be justified in placing this one species in each subdivision. It is well to avoid this duplication as far as possible, but not at the expense of definiteness. Sometimes the single species that causes the trouble may first be separated on a distinct character, and the remainder divided as the author prefers.

In most respects, the remarks concerning indented keys also apply to bracket keys. In the latter, however, the arrangement is so purely mechanical that suggestions of value in the former lose all their force when applied to the bracket keys. Whether the shorter division comes first or last has no significance. The user has merely to follow the indicators, and, so far as the mechanism of the key is concerned, should come out at the right place in the end. The bracket key uses a minimum of space. This advantage, in the opinion of the present writer, is far outweighed by

the arrangement of the indented key, which presents to the eye a design that may be quickly assimilated. In successive applications of the key, the user can save much time by skipping over many intermediate steps and going with little effort to a known indentation to apply the later comparisons. The user is able to learn the key and appreciate the relation of the parts more readily. In the bracket key, the user must, at least for a long period, commence at the beginning and follow through all the steps each time he uses the key.

An additional device has been suggested for the bracket key[1] by which it may be as readily " run backward as run forward." Referring to the bracket key on page 105, if this device were used there would be placed in parenthesis the leader preceding. The key then would read:

1.	Flowers red	2
1′.	Flowers blue	5
2.	(1) Leaves simple	3
2′.	Leaves compound	4
3.	(2) Petals 4	Species 1
3′.	Petals 5	Species 2
4.	(2′) Leaflets 5	Species 3
4′.	Leaflets 9 or 11	Species 4
5.	(1′) Flowers sessile	Species 5
5′.	Flowers pediceled	6
6.	(5′) Inflorescence a raceme	Species 6
6′.	Inflorescence a panicle	Species 7

One example of a bracket key (to the species of *Isachne*) in bad form is the following from Ridley's " Materials for a Flora of the Malayan Peninsula " (**3** : 127. 1907):

Glumes I and II much longer than IV....1. *I. Kunthiana.*
Glumes I and II about as long as IV.
Glumes III and IV equal and similar, hemispherical. Tall plants.
Panicle very lax, leaves 4–8 inches.....2. *I. albens.*

[1] Williamson. Keys in Systematic Work. Science **55** : 703. 1922.

Panicle rather compact, leaves 2 inches. . .3. *I. javana.*
Panicle thick. Leaves broad, spikelets pubescent.
4. *I. sylvestris.*
Glume III longer ovate flat, tall plant. . . .5. *I. australis.*
Glume III short. Dwarf plant. . . . . .6. *I. miliacea.*

The actual preparation of a good key is in itself a test of the author's taxonomic skill and judgment. It is well to give this part of the work adequate attention, and the result should be sufficiently tested. Not infrequently a worker is forced to revise his judgment as to the validity of a proposed new species because he is unable to find definite key characters by which it can be distinguished. Occasionally the key shows that a supposed new species really belongs with a valid species other than the one from which the author was trying to separate it.

In a long key, it is often desirable to note exceptions in a parenthesis at the point where a departure from the usual occurs or where a character might be overlooked.

The present writer has attempted to do this in his key to genera (Genera of Grasses of the United States) as, for example, " spikelets unlike, the sessile perfect, the pedicellate sterile (sessile spikelet staminate, pedicellate spikelet perfect in *Trachypogon*) " and " Glumes or sterile lemma awned (awn short and concealed in the silky hairs of the spikelet in *Tricholaena*)."

A synopsis is usually in the form of a series of headings distributed through the text or segregated at the beginning of the group they concern. A synopsis does not necessarily lead to the ultimate members of the group, as does a key. In Gray's " Manual " (ed. 7) the families have synopses of the genera at the beginning. Under Cruciferae, for example, there is first a synopsis and then an artificial key to the genera. The sequence of numbers in the synopsis is the same as that in the text, but the numbers in the key depart widely from this sequence. Since a synopsis is based upon affinities, it becomes essentially a series of abbreviated

statements showing combinations of characters. Furthermore, the statements are not necessarily contrasting and the subdivisions are not in two's or uniformly in groups of any other number. In a long synopsis distributed through the text, it is well to use devices to aid the user in finding the coördinate subdivisions. The reader should in some way be apprised of the number of headings of each successive rank and the page on which each may be found, and also of the number of species (or other groups) under each heading. For example, in a genus of 100 species extending over 75 pages, the author might indicate, after the statement of the characters for the first subdivision of the first rank, the scope of that subdivision (heading A) in this manner: (Species 1–30. B on page 25; C on page 60). If the headings of next rank are small italics, the first subdivision (*a*) may read in a similar manner (species 1–3. (*b*) on page 5; (*c*) on page 10; (*d*) on page 19). This saves the reader time in finding coördinate headings. The synopses in Ascherson and Graebner's " Synopsis," being without these mechanical aids, are difficult to follow.

In the actual construction of a key, one may find it helpful to write the names of the groups to be separated on individual cards. As the key is constructed, the cards are separated accordingly. If at any stage a group is to appear in each of two divisions, a duplicate card is made. In this way no group will be overlooked. This method is especially to be commended when one is preparing a local flora or a manual. In a taxonomic revision the author has probably constructed a tentative key to keep pace with the revisional work, and there is little probability of overlooking a species.

CHAPTER XII

PUBLICATION OF GROUPS

Genera, species and other taxonomic categories are said to be published when, in connection with the name, a description or sufficient characterization is printed and distributed. There are, then, two factors in publication: (1) a description that is sufficient to identify the group to which the name is applied; and (2) the accessibility of this description to botanists. In practice these conditions are not always met. It not infrequently happens that the description consists of a few words which may have seemed to the author to be sufficiently definitive but which to later botanists appear vague and indefinite. It is customary to give the author the benefit of the doubt and to consider his name published if there is an attempt to define the group or to distinguish it from others, especially if the description is given in a formal manner. A new name appearing without description is called a *nomen nudum* (bare name, name only). Casual mention of plants in travelers' notes, where a name appears in connection with a remark or two as to habit but without the information necessary to identify the species, does not constitute publication. Such names are sometimes referred to as *nomina seminuda.*

A description is accessible if printed in a book or serial which is placed on sale, or publicly distributed in sufficient quantity to supply the normal demand. If printed in a serial it should be one that ordinarily reaches botanists or is accessible to them. A description printed in an obscure newspaper would scarcely be considered properly published. Even if it were printed in a seed catalog, proper publication would be questioned. If the seed catalog were issued by a botanical garden and widely distributed to botanists, and

if it belonged to a series normally kept on file in libraries, proper publication would be conceded by most botanists.

A description is not properly published unless a sufficient number of copies are issued to make it generally accessible. A few copies printed and distributed privately are not always accepted as proper publication, because the work has not been given to the public. Carbon, mimeographic, photographic, and other multiple copies made by processes other than printing, may be channels for publication in the technical botanical sense if sufficiently accessible. Cases are on record where a sufficient number of properly printed copies were made, but all but one or two, or at most a few, were destroyed by fire before distribution was accomplished. Doubtful cases of the kind mentioned above would be considered on their merits. Names offered as new through such channels are accepted as properly published only if it can be shown that the description reached a sufficient number of botanists interested in the group proposed.

Publication of Species

As stated in a previous paragraph, the one who first applies a name to a species (or other group) in effective publication is said to be the author of the species or group, and when the name is used in a formal manner it is followed by the name of the author. A specific name may be published in two ways.

1. The species is proposed as new, named and described for the first time. This is the original description of the species. The author may place his own name after the name of the species, or he may omit his name and merely indicate that the species is new by appending "n. sp.," "spec. nov." or other equivalent term. Earlier authors sometimes used the abbreviation "nob." (*nobis*, by us) or "mihi" (or m., by me), for their new species, or indicated them by an asterisk. If the new species appear in a book or article written by the author there is no ambiguity. Sometimes, however, an author publishes a species under a

name which has been given to it by another botanist. This name may have been given to a plant in an herbarium, or mentioned in a letter to a friend. An author is under no legal obligation to publish such a name for another, but if he choose to publish it he credits the species to the other author. Whether one is under a moral obligation to publish an herbarium name depends upon the circumstances. If there is evidence that the herbarium name was given as a result of a serious study, or if the name occurs in a well-considered manuscript, the publishing author does well to publish it (if he is taking up the species on the basis of the specimen), crediting the species to the other, and might be criticized for piracy if he did not do so. On the other hand, names are often written on herbarium sheets in a casual manner, without proper study, or with the desire to call attention to peculiar specimens for further study. Authors are under no obligation to take up such names, and are wiser not to do so, for it may lead to confusion if the name, as sometimes happens, has been applied to two or more species. It is especially unfortunate to publish a name, crediting it to another, when the other's actual specimen has not been seen. (For an interesting example illustrating this, see the case of *Paspalum Pittieri* Hack. elaborated on page 149.)

Sometimes a writer prepares the descriptions of new species to be included in the work of another. For example, one may be preparing a monograph on a family of plants and may ask another botanist to furnish the manuscript for a genus. The second writer would then be credited with the new species of that genus. Or one botanist may edit a series of works to which others contribute families, tribes, or genera, each contributor then being credited with the new species he describes.

Example. De Candolle issued a series of monographs, one of which was devoted to the Andropogoneae, a tribe of grasses. The manuscript for this group was furnished by Professor Hackel. Hackel's new species published here may be cited thus: *Andropogon* ——— Hack. in DC. Monogr. Phan. **6** : —. 1889.

2. A name is published by a reference to a previous description. This method may be applied in three ways:

(*a*) A species may be transferred from one genus to another. This is sometimes referred to as a new combination, because the old specific name has been combined with a new generic name. The author making the transfer is credited with the new name as explained in Chapter IV. The publication of the new name is validated by a reference to the original name.

Example. *Sporobolus indicus* (L.) R. Br. (*Agrostis indica* L.). Robert Brown thus publishes the new name by referring to an older name already published. In older works one finds publication of this kind accomplished in a variety of ways. One might find: *Sporobolus indicus* (L. sub *Agrostis*). The author of the new combination is not named, but it is to be inferred that he is the author of the article in which the name occurs. In the parenthesis we see that the species was described by Linnaeus under *Agrostis*.

(*b*) It may be found that a name of a species properly described is not valid (can not be legally used) because it is a homonym, and a new name must be given. The new name will be effectively published if the non-valid name is cited.

In transferring a species to another genus it may be found that the name is not valid because the specific name is already in use in that genus for another species; it is then necessary to supply a new name.

Example. *Muhlenbergia biloba* Hitchc., 1913 (*Bealia mexicana* Scribn., 1890, not *Muhlenbergia mexicana* Trin., 1824). Hitchcock concluded that *Bealia mexicana* was properly a species of *Muhlenbergia* and transferred it to the latter genus. As there was already in that genus a species with the name *Muhlenbergia mexicana*, it was necessary to give *Bealia mexicana* a new specific name under *Muhlenbergia*.

Again, after a species is originally described in a genus, it may be found that it is not valid because the same name has been used earlier for another species; a new name is then required.

Example. *Panicum concinnius* Hitchc. & Chase, 1910 (*Panicum gracilicaule* Nash, 1903, not *P. gracilicaule* Rendle, 1899). Nash described *Panicum gracilicaule* in 1903, not knowing that Rendle had published the same name for a different species in 1899. Consequently it was necessary to give Nash's species a new name.

Many botanists now distinguish between the three categories of publication described above by designating them as new species, new combinations and new names.

Examples. (1) *Panicum leucothrix* Nash, n. sp. or sp. nov. (species nova); or more frequently the author's name is omitted, to be inferred from the author of the article. (2) *Sporobolus indicus* (L.) n. comb. (with a citation of original name to effect publication). The formal use of the term "new combination," has scarcely received the sanction of the best usage; illustrated in the example given. It may, however, be properly used to designate the kind of publication. For example, one might say, "Rydberg has transferred several species of *Sporobolus* to *Muhlenbergia* and has made new combinations for them." (3) *Muhlenbergia biloba* Hitchc. new name or nom. nov. (nomen novum).

(*c*) A specific name may be assigned to a species previously described under a misapplied name, or to one described but not named. An author may identify a given species with one previously described, and a subsequent author, discovering the error, may assign a new name.

Examples. *Panicum Scribnerianum* Nash (*Panicum scoparium* Lam. as described by S. Wats.). Sereno Watson (in Gray's Manual, ed. 6, 1890) described a species under the name *Panicum scoparium* Lam. Nash, finding that this species was not the same as the *P. scoparium* of Lamarck, assigned a new name. Sometimes the botanist giving the new name may indicate the change thus: *Panicum Scribnerianum* (*P. scoparium* Amer. Auth. not Lam.). Another method, unfortunately rather common, is to cite the synonym thus: (*P. scoparium* S. Wats. not Lam.). Such a citation is misleading since it seems to indicate a case like that described under *b* (see example, *Panicum concinnius*) whereas it is really a misapplication of a name by Watson, not a new name proposed by him as is implied.

Panicum Muhlenbergianum Schult. (Panicum No. 27 Muhlenberg). Muhlenberg described a species but gave it no name, merely giving it a number. Schultes assigned a name, referred to the number in Muhlenberg's work, but gave no description. Schultes's name was effectively published.

Publication Based on Figures. — There is a difference of opinion among botanists as to whether a new species based upon a figure, without description, is effectively published. In paleobotany such publication is usually accepted as effective. With diatoms also, new species are considered valid if based on figures. Among higher plants, however, new species based solely on figures are usually rejected. It is best to consider each case on its merits. If the figure or plate is carefully made and includes details of the flower, fruit, or other characters of diagnostic value, especially if accompanied by a full explanation, it is probable that the new species is as fully identified as if supported by a formal description, and therefore should be considered as effectively published. However, there are many figures so crudely or inaccurately drawn that identification is impossible or at least uncertain, and species based upon them would be a subject of controversy. It is nevertheless true that equal uncertainty may be occasioned by the acceptance of names based on insufficient description. The Type-basis Code provides that names based on figures are not effectively published except in paleobotany and in the literature of diatoms. (See Appendix, page 202.)

Publication of Genera[1]

Genera may be published by the distribution of a printed description, as in the case of species. We have here, however, a somewhat different set of conditions. The species is the unit of classification, while a genus is a group of species. Hence, when a genus is first described, the included species are mentioned. The description of the genus states the characters common to the species included and the particulars in which the group differs from other genera in the same family. It is more important to know the species of the group than to know the generic characters, for if the species are known the characters common

[1] See Appendix, The Type-basis Code, page 201.

to the group can be determined even though no generic description has been given.

It is now customary in describing a new genus to indicate the type, that is, one species that shall determine the application of the generic name.

Publication of genera therefore may be effected by (1) describing the genus and assigning a binomial specific name, (2) describing a species and assigning a generic and specific name, (3) giving a generic and specific name and citing a previously published description, or (4) applying a generic name to a previously published binomial species or group of species.

As effective publication of generic names is very important from the standpoint of stability in nomenclature, these four cases will be somewhat elaborated. It is assumed in all cases that the requirements of printing and distribution have been met.

1. Description, with at least one binomial specific name. This has already been discussed in the preceding paragraphs. Even though the description be meager or obscure, the genus can be interpreted from the included species if these have been previously described.

2. Description of species with an accompanying binomial. This in effect assigns a generic name to a species or group of species. In the first work published under binomial nomenclature, Linnaeus' "Species Plantarum," there are no generic descriptions, the genera being given by name, each followed by the descriptions of the included species. Under the Type-basis Code these genera are effectively published. Some botanists maintain that this method does not effectively publish genera, and insist that effective publication requires a generic description simultaneously or previously published. These botanists validate the genera of Linnaeus' "Species Plantarum" by the fifth edition of his "Genera Plantarum" published the next year (1754).

Example. The genus *Eragrostis* was established by Host in 1809. He describes *Eragrostis major* but gives no generic description.

3. Publication by the citation of a synonym. A subdivision of a genus may be raised to generic rank. A new name may be given to a genus as a substitute for one that is not valid. A species or group of species may be detached from an old genus to form a new genus. In all these cases there may be no new generic description, publication being effected through the citation of synonyms that have been properly published.

Examples. *Bromelica*, first described as a section of *Melica* by Thurber, was raised to generic rank by Farwell. *Chaetochloa* was proposed by Scribner as a substitute for *Setaria* Beauv., the latter name being invalidated by the earlier use of the name for a genus of lichens by Michaux. *Bulbilis* was established by Rafinesque, who gave this name to *Sesleria dactyloides* Nutt.

4. Application of a generic name to a previously published binomial species or group of species. This differs from the preceding method (3) only in case no direct synonym is cited.

Examples. Adanson applied the name *Apera* to the first species of *Agrostis* in Linnaeus' "Species Plantarum," without definitely citing the name of the species. Necker applied the name *Psedera* to the Linnaean species of *Hedera* with compound leaves.

The difficulties connected with defective and insufficient publication are to be found mostly in books written before botanists developed their present methods of procedure. To avoid confusion and to establish effective publication, authors are expected to publish names in books, journals or serials accessible to botanists. In order that such a publication may be considered accessible, the number of copies should be ample and the medium one that ordinarily reaches botanists. Botanical journals are to be preferred, though journals devoted to general science, if well-known and widely circulated, are not objectionable. Publication in literary journals or in those devoted especially to sciences other than botany would be legal but is certainly to be discouraged. Publication in ephemeral pamphlets or leaflets

should be avoided.[1] The publication of names in books of travel is unfortunate, especially if this is done in a casual way. Any form of publication which is likely to escape the indexers, or which puts upon them an extra burden, is to be avoided. It is well to print new names in conspicuous type so that they will not be overlooked. Not infrequently, new names have failed to receive attention even when published in taxonomic works, because they have been inserted inconspicuously. This is especially true of changes of names recorded in footnotes or remarks appended to other matter and with no distinctive type to give them prominence.

For some years after the birth of descriptive taxonomy, new species were described in Latin, as that was the language of international science. Gradually the exclusive use of Latin was abandoned and descriptions began to appear in English, French and German, at first usually with Latin diagnoses and later entirely in the modern language. At present the descriptions, for the most part, appear in the languages mentioned, but there is an increasing tendency to use other languages. As long as the foreign language is one that uses Roman letters, it is possible for botanists to work out the descriptions; but the use of such languages as Russian and Japanese renders the new material unavailable to the great majority of botanists, and, therefore, can scarcely be said to meet the requirement of accessibility. The International Rules (Vienna Code) provide that publication, to be effective, must be in Latin or be accompanied by a diagnosis in Latin.

[1] The present writer has been guilty of transgressing this rule. *Roripa Armoracea*, *R. sessiliflora* and *R. sinuata*, all transfers, were published in his "Key to the Spring Flora of Manhattan" (1894), a pamphlet privately published for the use of students and soon out of print. Such works might be classed as ephemeral. Fortunately, the names were recorded by indexers and, at most, they were only transfers and not original publications.

CHAPTER XIII

HOMONYMS AND SYNONYMS

In the preceding chapters, frequent reference has been made to synonyms and occasional reference to homonyms. The subject is of so much importance in descriptive taxonomy that a further elaboration is advisable.

Homonyms

Homonyms are identical names applied to different groups of the same rank. They may have been applied by accident or by design. An author may publish a new name for a species without knowing that the same name has been used for another species. If the name has not been given sufficient publicity in connection with the first species, it may come into general use with the second. The second publication may have been due to carelessness, the author not taking sufficient pains to determine whether or not the name had been used. Until the issue of the " Index Kewensis," which listed the names of genera and species of flowering plants published up to about the time that work appeared, it was not an easy matter to determine homonyms. Even at the present day, a homonym may be published because the earlier name has been so recently published that there has been insufficient time for it to reach botanists. Every effort should be made to avoid the publication of homonyms as it burdens literature with extra names and is an indication of carelessness on the part of the worker.

Some botanists have published a name a second time designedly, because the earlier application of the name had fallen into disuse, sometimes because it was generally recognized as a synonym, sometimes because it had not been generally accepted. In the early days of descriptive

taxonomy, the principle of priority of publication was not so generally accepted as it is at present, and botanists were more likely to accept names on authority, regardless of priority.

Synonyms

Synonyms are different names applied to the same group. They are of two general kinds: first, those that are identical in their application, being based on the same concept, the same specimen, or the same type; and second, those whose identity is a matter of taxonomic opinion. The first class may be called absolute synonyms, or typonyms. Typonyms occur accidentally when two botanists independently describe a new species based upon the same specimen or upon different specimens of the same collection. Substitute names are absolute synonyms, in cases where the name of a group is found to be invalid and a new name is given. The most common kinds of absolute synonyms are those which result from the transfer of species from one genus to another or of varieties from one species to another, or from the change in rank from variety to species or species to variety.

It not infrequently happens that an author transfers a species from one genus to another but misapplies the name. For example, Humboldt, Bonpland and Kunth transferred *Axonopus aureus* Beauv. (1812) to *Paspalum*, as *P. aureum* H.B.K. (1816) but applied the name to a different species, as is shown by their description and plate. Many botanists, the present writer included, consider *P. aureum* to be based upon *A. aureus* and hence a typonym of the latter, and look upon the application of the name *P. aureum* to the plant described as being an error, a misapplication of a name. Hence, the plant described by Humboldt, Bonpland and Kunth will be called by another available name, *Paspalum chrysoblephare* (Lag.) Doell (*Axonopus chrysoblepharis* (Lag.) Chase). Other botanists look upon *P. aureum* as a new name to be applied to the plant described, in consequence of which, the species described as *Axonopus aureus* by

Beauvois must receive a new name when transferred to *Paspalum*. In the writer's opinion, this second procedure is more confusing than the first and should not be followed.

Synonyms of the second class are not consistently applied and depend upon taxonomic opinion. The names were applied originally by their authors to groups thought by them to be distinct. Two generic names may be applied by some botanists to two distinct allied groups. Other botanists may believe these groups to belong to one genus, to which they apply one of the names, the other being regarded as a synonym. The term synonym is used somewhat loosely, in two ways. Two names applied to one group are synonyms, but the term " synonym " is also used in contrast with " valid name." Of two synonyms one may be valid; the other is said to be a synonym of the valid name. It is in this second sense that the term synonymy is usually applied. In a taxonomic article, a valid name may be followed by a list of synonyms, this list constituting the synonymy. Taxonomists do not agree as to the limits of species or genera; consequently the synonym of one botanist may be the valid name of another.

Examples of Homonyms and Synonyms

(*a*) *Setaria* Achar.; Michx. Fl. Bor. Amer. 1803.
Setaria Beauv. Ess. Agrost. 51. 1812.

These names are homonyms, the first being a genus of lichens, the second a genus of grasses. Scribner substituted the name *Chaetochloa* for *Setaria* Beauv. because the latter was invalidated by the earlier *Setaria* of Acharius as published by Michaux.

(*b*) *Homalocenchrus* Meig, Act. Helv. Phys. Math. **4** : 307. 1760. The type species is *Phalaris oryzoides* L.

Leersia Swartz, Prodr. Veg. Ind. Occ. 21. 1788. The type of this genus is also *Phalaris oryzoides*. Hence *Homalocenchrus* and *Leersia* are typonyms. The first name,

having priority, is valid, the second being a synonym. The International Rules conserve *Leersia*, that is, arbitrarily validate this name even though it was published later than *Homalocenchrus*. Hence, under these rules, *Homalocenchrus* is the synonym.

(*c*) *Bromus* L. Sp. Pl. 76. 1753.
Ceratochloa Beauv. Ess. Agrost. 75. 1812.
Zerna Panz. Denkschr. Baier. Akad. Wiss. München **4** : 296. 1813.
Serrafalcus Parl. Rar. Pl. Sic. **2** : 14. 1840.
Forasaccus Bubani, Fl. Pyren. **4** : 380. 1901.

These names are usually considered now to apply to the same group. *Bromus*, having been published first, is the valid name; the others are synonyms. The generic names listed are based on different species and hence are not typonyms.

(*d*) *Anthochloa* Nees; Meyen, Reise um Erde **2** : 14. 1835.
Stapfia Davy, Erythea **6** : 110. 1898. Not *Stapfia* Chodat. 1897.
Neostapfia Davy, Erythea **7** : 43. 1899.
Davyella Hack. Oesterr. Bot. Zeitschr. **49** : 133. 1899.

Davy published *Stapfia* as a new genus, not recognizing it as being the same as *Anthochloa*, and not knowing that the name *Stapfia* had been used the preceding year for another genus. There had scarcely been time for Chodat's name to become generally known, and, moreover, it did not come to Davy's attention for some time as the first genus belonged to the algae and the second to the grasses. The next year, Davy discovered that his name was a homonym and changed it to *Neostapfia*. The same year, and only a short time after the publication of *Neostapfia*, Hackel, without knowing of *Neostapfia*, changed *Stapfia* to *Davyella* for the same reason that had led Davy to make a change. Still later, Scribner investigated the genus and

concluded that it was the same as *Anthochloa*, which was published many years earlier and based on a closely allied species.

(*e*) *Panicum pilosum* Swartz, Prodr. Veg. Ind. Occ. 22. 1788. Described from Jamaica.

Panicum distichum Lam. Encycl. **4** : 731. 1798. Described from Jamaica.

Panicum pilisparsum Meyer, Prim. Fl. Esseq. 57. 1818. Described from British Guiana.

Panicum trichophorum Schrad. in Schult. Mant. **2** : 247. 1824. Described from Brazil.

The present writer has examined the type specimens of all the above, and in his opinion they all represent the same species. The name first published is the valid name and the others are synonyms.

(*f*) *Panicum Urvilleanum* Kunth, Rév. Gram. **2** : 403. 1830. Described from Chile.

Panicum megastachyum Presl, Rel. Haenk. **1** : 305. 1830. Not *P. megastachyum* Nees, 1826. Described from Peru.

Panicum Preslii Kunth, Enum. Pl. **1** : 121. 1833. Based on *P. megastachyum* Presl.

Presl's name for this species was published first, but is invalidated by the earlier homonym of Nees. Kunth observed that Presl's name was a homonym and changed it to *P. Preslii*, but he had not seen the plant and did not know that it belonged to the same species as his *P. Urvilleanum*. *Panicum Preslii* Kunth is a typonym of *P. megastachyum* Presl, and both are synonyms of *P. Urvilleanum*.

(*g*) *Eragrostis maypurensis* (H.B.K.) Steud. Syn. Pl. Glum. **1** : 276. 1854. Based on *Poa maypurensis* H.B.K.

Poa maypurensis H.B.K. Nov. Gen. & Sp. **1** : 161. 1816.

Poa Vahlii Roem. & Schult. Syst. Veg. **2** : 563. 1817.

Eragrostis Vahlii Nees, Agrost. Bras. 499. 1829. Based on *Poa Vahlii* Roem. & Schult.

Eragrostis amoena Presl, Rel. Haenk. **1** : 275. 1830.

Eragrostis panamaensis Presl, Rel. Haenk. **1** : 227. 1830.

Megastachya amoena Fourn. Mex. Pl. **2** : 118. 1886. Based on *Eragrostis amoena* Presl.

Megastachya panamaensis Fourn. Mex. Pl. **2** : 118. 1886. Based on *Eragrostis panamaensis* Presl.

Here is a valid name with seven synonyms. Among them are three pairs of typonyms.

(*h*) *Panicum Havardii* Vasey, Bull. Torrey Club **14** : 95. 1887.

Panicum virgatum macranthum Vasey, Bull. Torrey Club **13** : 26. 1886. Not *P. macranthum* Trin. 1826.

Vasey first published this form as a variety. Later he concluded it was a distinct species but could not use the varietal name because that had already been used by Trinius for a different species. He consequently changed it to *Havardii*, thus commemorating the name of the collector, Dr. Havard. The two names of Vasey are typonyms. All typonyms are synonyms, but not all synonyms are typonyms.

CHAPTER XIV

TYPES

Nomenclatural types[1] fix the application of names. They are used especially in reference to genera and species. The type specimen fixes the application of the specific name; the type species fixes the application of the generic name. A specific name must always be applied so as to include the type specimen; a generic name must always be applied so as to include the type species. This idea is known in systematic biology as the type concept. It applies to subdivisions of the species, and, in a general way, to families and other groups.

Type Species of Genera

The type species must be one of the species included in the genus when originally published. If the genus included but one species when originally published, that species becomes without question the type species. If there were more than one species included in the genus when originally published, one of them is the type species. It is now customary for authors to indicate the type species when publishing a new genus. In the early days of taxonomy there was no definite concept of types and the type of a genus was rarely indicated as such. In the process of establishing nomenclature upon a type basis, it becomes necessary to select the type species for genera containing more than one species when originally published, in cases where no type was indicated by the author. In general, the type is assumed to be the species that the author had chiefly in mind when establishing the genus. It is evident that the

[1] A nomenclatural type must not be confused with a biological type. The latter is a representative of the group to which it belongs; the former determines the application of a name.

selection of the type species must be guided by a taxonomic knowledge of the genus and should not be attempted by one unfamiliar with the species concerned. Much confusion has been needlessly injected into taxonomy by the study of names apart from a study of the plants to which these names are applied. In selecting the type species, the following items should be considered.

Although the author may not have indicated a type species, he may have indicated a certain group or section of the genus as being more typical, or, on the other hand, may have indicated a species or group as being aberrant or as showing a transition to another genus. In the one case, the type should be chosen from the more typical group; in the other case, the less typical species should be excluded from consideration in selecting the type.

The description of the genus may point toward certain species as being typical. Species which definitely disagree with the generic description should not be considered in selecting the type (provided some of the species do agree). Linnaeus' " Species Plantarum " (1753), the work in which the binomial system of naming first appeared and from which our binomial nomenclature starts, contains no generic descriptions. Botanists have agreed to associate with this work that author's fifth edition of the " Genera Plantarum," published in 1754. Therefore, in selecting types of these Linnaean genera, one compares the species of the " Species Plantarum " with the descriptions of the genera in the " Genera Plantarum." In the latter work the generic name is often followed by a citation from an older author, such as Tournefort, showing that the genus was adopted from a previous work. Such citations should be considered in selecting the type.

It may usually be assumed that the species that is illustrated in connection with the description of the genus is one which, to the author, is representative of the genus. Hence, other things being equal, the species illustrated would be chosen as the type.

Among Linnaean genera and sometimes among others, the name given to a species by an author may indicate that he had that species in mind as being representative. Such names as *communis*, *vulgaris*, *typicus*, *normalis* and *officinalis* would seem to point out typical species.

In the early days of binomial nomenclature, specific names were sometimes proper nouns. In segregating from a given genus a group of species including one with such a name and proposing this group as a distinct genus, the author of the new genus not infrequently adopted this proper noun as the name of the genus. In such case we may assume that the author considered this species typical of the new genus and it may be selected as the type.

If the genus contains, from the standpoint of the author, both native and foreign species, we may assume, other things being equal, that he is more familiar with the native species. In selecting types of Linnaean genera on this basis, one would choose a Swedish species rather than one from southern Europe, or a European species rather than an African, or one grown under Linnaeus' direction in the Upsala garden or in Clifford's garden and previously described in his " Hortus Upsaliensis " or his " Hortus Cliffortianus," rather than a species known to him only as an herbarium specimen or from a description. For the same reason, one would assume as especially familiar a commonly cultivated economic plant or one much used in medicine, officinal plants being especially prominent in those days. Between two species, one known to the author through an herbarium specimen and the other only through a description, one would probably choose the first as the type, the idea being in all such cases that the more familiar species is likely to be to the author more representative of the genus.

If an author includes a well-known old species, segregated from another genus, and also a new species, one would assume, other things being equal, that the old species was, to the author, representative and hence the type.

In choosing types of Linnaean and other older genera, it is well to note the historical development of the genus. It is confusing to change the application of a generic name in common current use, especially if the genus now contains a large number of species or contains species important in agriculture or horticulture. Unless it violates some important taxonomic consideration, the type should be chosen so as to retain the application of the generic name according to current usage, when such usage is so wide-spread as to be practically unanimous.

Among equally eligible species, preference should be given to the one first known to have been designated as the type.

If none of the above items apply in the choice of the type, one may be justified in arbitrarily selecting the first of equally eligible species.

It will be seen from the above that a careful study of all the factors in the case, both nomenclatural and taxonomic, is necessary before the type species of critical genera can be selected. In many cases the factors are few and the conditions are simple, and all botanists would come to the same conclusion in selecting the type. In complicated cases the selection should be made only by those familiar with the genus. Every author of a taxonomic revision or monograph should state what species he considers to be the type and should give his reasons for the selection. Differences of opinion will undoubtedly develop among taxonomists as to the type species of certain genera. It is to be hoped that ultimately these differences may be submitted to a properly constituted International Commission for decision. Until such a commission is established by an International Botanical Congress, much progress is possible through the recording of relevant facts in connection with type selection by monographers in following the general principles as outlined above.[1]

[1] The author of this book has followed the recommendations of the Committee on Nomenclature of the Botanical Society of America as published in the year book of the Society for 1919 and 1920, and in Science (**49** : 333–336. 1919; **53** : 312–314. 1921). See also the author's article, "The Type Concept in Systematic Botany" (Amer. Journ. Bot. **8** : 251–255. 1921).

Examples of Generic Types

In most cases there is no difficulty in determining what species is the type of a genus. Many genera included but one species when originally published, in which cases the single species is necessarily the type of the genus.

Aristida L. Sp. Pl. 82. 1753. Only one species, *A. adscensionis*, is included.

Scribneria Hack. Bot. Gaz. **11** : 105. 1886. This was based on a single species *Lepturus Bolanderi* Thurb., which is the type. That is, Hackel bases a new genus on the species which Thurber described under *Lepturus*.

Many genera when originally described included more than one species. If no type was designated by the author, the type concept demands that one of the species be selected as the type. To determine the type, one endeavors to find out what species the author had chiefly in mind when the genus was established. Several examples will be given and the principles involved in the selection discussed. As stated above, there is usually little difficulty in determining the type. The examples given below include several that present unusual complications. Among the difficult cases the Linnaean genera are prominent. An attempt is made to show the student the principles involved so that he may be prepared to solve his own difficulties in the selection of types.

Enneapogon Desv.; Beauv. Ess. Agrost. 81. 1812. Beauvois describes the genus and mentions without description five species, but the first one, *E. Desvauxii*, is the only one figured (pl. 16, f. 11), hence is selected as the type. Many genera may be typified through illustrations in the original publication.

Triniochloa Hitchc. Contr. U. S. Nat. Herb. **17** : 303. 1913. Three species are described, one of which is new. The other two were transferred from *Avena*. One of these, *Podosaemum stipoides* H.B.K., the oldest historically, is designated as the type.

When one generic name is substituted for another the type is not changed.

Neostapfia Davy, Erythea **7** : 43. 1899. A new name is proposed for *Stapfia* Davy (1898) which is invalidated by the earlier *Stapfia* Chodat (1897). The type of *Stapfia* Davy (*S. colusana*), the only species described, becomes the type of *Neostapfia.*

Achyrodes Boehmer in Ludw. Def. Gen. Pl. 420. 1760. The only species mentioned is one with a phrase name of Tournefort (1700), which Linnaeus cites under *Cynosurus aureus.* No description being given, this species becomes the type of *Achyrodes.*

Apera Adans. Fam. Pl. **2** : 495. 1763. Adanson cites a single species, " Agrostis 1. Lin. Sp. 61," which is *Agrostis spicaventi.* This species is thus the type of *Apera.*

Valota Adans. Fam. Pl. **2** : 495. 1763. The only citation given by Adanson is to " Sloan. t. 14. f. 2 " which is also given by Linnaeus under his *Andropogon insularis* (Syst. Nat. ed. 10, **2** : 1304. 1759), thus making that species the type.

Homalocenchrus Mieg, Act. Helv. Phys. Math. **4** : 307. 1760. The first species is referred to the genus with certainty and a second doubtfully. No specific names are used, but under the first there are two citations which appear in the " Species Plantarum " under *Phalaris oryzoides,* making this species the type of *Homalocenchrus.* Under the Type-basis Code, *Achyrodes, Valota,* and *Homalocenchrus* are not effectively published as no binomials are directly mentioned.

Hordeum L. Sp. Pl. 84. 1753. Linnaeus describes six species. Since no generic descriptions are given in this work, Linnaeus' " Genera Plantarum " (1754) is used to find his concept of the genus *Hordeum.* In this work he cites Tournefort's plate 295, representing *H. vulgare,* the common barley, which is one of the six species described in the " Species Plantarum." The reference to Tournefort shows that Linnaeus takes the name *Hordeum* from that

author. The description of the genus shows that Linnaeus had the same concept. Hence *H. vulgare* is selected as the type.

Triticum L. Sp. Pl. 85. 1753. Seven species are described. The "Genera Plantarum" (1754) cites Tournefort's figures 292 and 293, beardless and bearded wheat, respectively. Linnaeus names the bearded wheat *T. aestivum*, and the beardless wheat *T. hybernum*, these being his first and second species. As these two species were especially familiar to Linnaeus, being commonly cultivated, and as they are the basis of the name which he adopts from Tournefort, the type should be selected from these two rather than from the other five species that he describes. The description of the genus applies equally well to either and they may be considered equally eligible as the type species. In such a case it is well arbitrarily to select the first species, *T. aestivum*.

Lolium L. Sp. Pl. 83. 1753. Linnaeus describes two species, *L. perenne* and *L. temulentum*. These are both now retained in the genus and both were described in the flora of Sweden. Since the first was well known to Linnaeus as a common and useful meadow grass, this may be taken as the type species.

Leersia Swartz, Prodr. Veg. Ind. Occ. 21. 1788. Three species are described, *L. monandra*, *L. hexandra*, and *L. oryzoides*. *Phalaris oryzoides* L., the basis of the third species, is the oldest historically; hence this species is selected as the type.

Axonopus Beauv. Ess. Agrost. 12, 154. 1812. Beauvois mentions several diverse species under his new genus, the first being *Milium compressum* Swartz which is chosen as the type, since it is the only species that agrees with his description of the genus in having solitary spikelets. *Axonopus aureus* also has solitary spikelets, but, being mentioned in a supplementary paragraph as having been received after his work was completed, can not be the type.

Danthonia Lam. & DC. Fl. Franç. 3 : 32. 1805. The work cited is a local flora in which the two French species are described, *D. decumbens* (which is the same as *Sieglingia decumbens*) and *D. provincialis*. The authors, however, mention in the paragraph preceding the one devoted to the generic description that " besides the species described below one ought to refer to this genus, first, *Avena spicata* L. or *Avena glumosa* Michx.; second, *Avena calicina* Lam. not Vill." Of the four species mentioned, three are congeneric with *Avena spicata* and correspond with the generic description better than does *Danthonia decumbens*, which is the first species described under *Danthonia*. Piper has selected this latter species as the type because it is the first species described under *Danthonia*, thus transferring the application of the name to what is generally called *Sieglingia*, and has taken up *Merathrepta* Raf. for what is generally called *Danthonia*. It is the opinion of the present writer that *Danthonia decumbens* should be excluded from consideration in selecting the type. *Avena spicata* L., being the oldest historically, would be the type.

Linnaean Genera

The Linnaean genera of the " Species Plantarum " present fundamental problems in type selection because they are the first genera published under the binomial system of nomenclature. In many cases, species have been taken out of these genera and placed in new ones by later authors and the generic concept has been greatly changed. It is important to determine how the generic name should be applied as the generic concept changes. By selecting one of the original species as the type, the application of the generic name is determined, since the name must always go with the group containing the type. Several examples are given below.

Poa L. Sp. Pl. 67. 1753. Seventeen species are described. In the " Genera Plantarum " no citation is given, showing that the name *Poa* is not adopted from a previous author as was *Hordeum* (see above). There is nothing in

the generic description to show that Linnaeus had in mind one species more than another, as the description applies to all. It is necessary, therefore, to find out, if possible, which of the species were more familiar to Linnaeus. We may assume that the Swedish species would be the familiar ones. Linnaeus first used the name *Poa* in his "Flora Lapponica." Among the species there described is the one he later called (in the "Species Plantarum") *Poa pratensis.* This, being the most common and familiar species known to Linnaeus, is chosen as the type. Of the seventeen original species (in the "Species Plantarum") nine are now referred to other genera. Although the authors who made these transfers recognized no type concept, they were careful to apply the name *Poa* to the group containing the most familiar species, *Poa pratensis.*

Briza L. Sp. Pl. 70. 1753. Linnaeus describes four species. The first three were familiar to him as cultivated plants in the Hortus Cliffortianus. Of these the second (*B. media*) which was described in his flora of Sweden, is selected as the type species.

Uniola L. Sp. Pl. 71. 1753. Two species are described, *U. paniculata* and *U. spicata.* The generic description applies rather better to the first species. Both species were described as coming from America and may have been equally familiar. The second species is now referred to *Distichlis.* The first species is selected as the type.

Elymus L. Sp. Pl. 83. 1753. Five species are described, all now retained in the genus. The first use of the name *Elymus* by Linnaeus was in his "Hortus Upsaliensis" (1748) where two species are described, the first being cited in the "Species Plantarum" under *E. virginicus* and the second under *E. sibiricus. Elymus sibiricus* is arbitrarily chosen as the type because it is the first of the five species in the "Species Plantarum" that is described in the "Hortus Upsaliensis."

Aira L. Sp. Pl. 63. 1753. Fourteen species are described. The name was first used for a genus by Linnaeus

in his " Flora Lapponica " (1737), where he described four species. These four he later (Species Plantarum) described as *A. spicata*, *A. caespitosa*, *A. flexuosa*, and *A. montana*. The description in the " Genera Plantarum " applies well enough to all four. Since the first species was later transferred to *Trisetum*, it is advisable to select as the type the second species, *A. caespitosa*.

Phalaris L. Sp. Pl. 54. 1753. Five species are described, two being now retained in the genus (*P. canariensis*, the first, and *P. arundinacea*, the third). The first species is chosen as the type because it is the one that best corresponds to the description of the genus in the " Genera Plantarum " (e.g., gluma obtusa) and is moreover the only one of the five species described that was known by the name of *Phalaris* to the older authors, such as Bauhin, as cited by Linnaeus.

Panicum L. Sp. Pl. 55. 1753. This case involves several interesting points. Twenty species are described. The first ten and the fifteenth are now referred to other genera. The historic type of *Panicum*, the species to which the name *Panicum* was applied by pre-Linnaean authors, is *P. italicum*. As usual in seeking Linnaeus' generic concept, we must go to the " Genera Plantarum " (1754). Here he describes the spikelets as having three ovate-acuminate glumes, the first smaller than the others, but says nothing about awns (as in *Panicum crusgalli*) or involucral bristles (as in *P. italicum*). In a note at the end, he mentions that some of the species have awns and some have involucral bristles. It would appear that Linnaeus considered these latter species as departures from the usual; hence they are excluded from consideration in selecting the type. Of the remainder, *P. miliaceum*, corresponding to the generic description, being an economic species and native from the standpoint of the author, hence probably the most familiar species, is selected as the type. This selection preserves the name *Panicum* in its commonly accepted sense.

Andropogon L. Sp. Pl. 1045. 1753. Twelve species are described. The reference in the "Genera Plantarum" is to "Roy. lugdb. 52" [Royen, Flora Leydensis, 1740]. Here are described two species, which later appear in the "Species Plantarum" as *Andropogon hirtum* and *A. virginicum*. The second is selected as the type since this retains the name in its present signification. Some botanists refer *A. hirtum* to *Cymbopogon* and some to *Hyparrhenia*.

Holcus L. Sp. Pl. 1047. 1753. This is one of the few examples in which an adherence to the type concept alters the application of a well-known generic name. Linnaeus describes seven species, *H. sorghum*, *H. saccharatus*, *H. halepensis*, *H. lanatus*, *H. odoratus*, *H. laxus* and *H. striatus*. The historical development was as follows: the first three species were segregated under *Sorghum;* *H. odoratus* was assigned to *Hierochloa;* *H. laxus* to *Uniola*; and *H. striatus* to *Panicum* (later to *Sacciolepis*), leaving *H. lanatus* to represent *Holcus*. What species had Linnaeus chiefly in mind in arranging the seven species under *Holcus?* Turning to the "Genera Plantarum," we find the citation to "*Sorgum* Mich.," which refers to the plants commonly known then as now, as *sorghum*. The description in the "Genera" applies to the first three species and not to the others. It is clear that Linnaeus considered the first three species to represent the genus *Holcus*, the others being included as an afterthought or for want of a better place to put them. Since the old name sorghum is used by Linnaeus as a specific name, *H. sorghum* is selected as the type of *Holcus*.

Type Specimens of Species

The same general principles apply to the selection of type specimens as to the selection of type species, but the method of application is modified by the different conditions prevailing.

The type specimen is the specimen, or one of the speci-

mens, from which the author wrote the description of the species. If the description was based upon a single specimen, that one is, of course, the type (unless an error can be demonstrated). If there was more than one specimen cited with the original publication, only one of these can be the nomenclatural type even though the description was drawn to cover several specimens. Many authors of the present day indicate the type specimen when describing species. In earlier days this was seldom done, and it becomes necessary now to choose types for the previously described species. In general, the type is the specimen which the author had chiefly in mind when describing the species.

One may sometimes infer the type from the remarks which the author records about the different specimens which he has consulted and which he cites. Any specimens mentioned as being exceptional or unusual would be excluded from consideration in selecting the type. The author may direct attention to a particular specimen, even though he does not call it the type. A specimen which is illustrated, especially if details of the floral structure are given, may usually be considered the type. Such a specimen can usually be identified only by consulting the author's herbarium. The type may often be selected on the basis of the specific name, when it is derived from the collector, locality, or host.

In many cases it is necessary to examine the specimens that were before the author when he drew up the description. The location of these specimens is often known, because the author did his work at a certain herbarium and the actual sheets of specimens may be found. Unfortunately, there are some cases where the types can not be found. The specimens described may have been borrowed and no record kept of the source. Some probably have been lost or destroyed. Many descriptions have been drawn from living plants in botanical gardens and no specimens saved. The earlier authors sometimes attached

no significance to the original specimens and often exchanged them or gave them away. Such types may ultimately be located.

When the original specimens are examined, one may often determine which one should be considered the type. The specific name may be written, in the handwriting of the author, on the label or sheet attached to one of the specimens; or one of the sheets may have notes or drawings, indicating that this specimen received special attention.

Even when only one specimen was cited with the original description, an examination of this type may be necessary to identify the species. At this point care is needed to determine which sheet is the type. The data on the sheet should correspond with those published in the original description. The searcher should be on his guard concerning the unfortunate fact that occasionally an author has published a species under a different name from the one he wrote on the sheet, or, what is still more misleading, may have applied the name found on a sheet to a different species in publication.

One general principle should be borne in mind: the type specimen interprets the description and fixes the application of the name; hence, primarily, the description controls the selection of the type. The fact that the author has written the specific name on a sheet does not in itself indicate that this specimen is the type. The specimen must correspond to the description (though due allowance must be made for errors of observation and misunderstandings of structure), and there must be evidence from the date and other data on the label that this specimen was the one from which the description was drawn. It is clear that a specimen received after the description was published can not be the type even though the sheet may bear the name in the author's hand.

Sometimes no specimen is cited with the original description. Trinius often gave only the country from which the species came. For example, *Panicum lasianthum* Trin.

Gram. Icon. 3: pl. 245. 1830. Trinius states that the specimen came from Brazil. An examination of his herbarium shows that the type was collected by Langsdorf. In other cases, only the range of the species is given. To determine the type specimen it is necessary to consult the specimens which the author had before him when writing the description. Usually one sheet can be singled out as the type because it has upon it the name in the author's hand or notes or drawings which indicate that it was the specimen the author had chiefly in mind as representative of the species. If there are two or more specimens equally eligible, the one most nearly corresponding to the description or the most perfect specimen should be selected as the type.

It will readily be seen from the preceding remarks that the fixing of type specimens is a work demanding the most thorough study of all the details and should be done by one familiar with the group under consideration.

When a species is transferred from one genus to another the type remains the same. Also, when a new name is an avowed substitute for an old one, the type of the old name becomes the type of the new name (see page 117, under Publication of Names). For example, when *Agrostis indica* L. was transferred to *Sporobolus*, the type of *A. indica* became the type of *S. indicus* (L.) R. Br. When *Panicum concinnius* Hitchc. & Chase was substituted for *P. gracilicaule* Nash (1903) because the latter was invalidated by the earlier *P. gracilicaule* Rendle (1899), the type of *P. gracilicaule* Nash became the type of *P. concinnius*. (See page 118.)

The species of Linnaeus, especially those described from Europe, are often based upon familiar concepts and not upon specimens. Such species have no type specimens. The identity of the Linnaean species is often determined largely by the citations of the descriptions of others. Sometimes these citations can be traced back to actual specimens, but oftener they can not. The Linnaean species described

from countries outside of Europe are likely to be based upon types and the specimens may be in existence. The Clayton specimens described by Gronovius and cited by Linnaeus are at the British Museum of Natural History. The specimens collected by Patrick Browne and by Hans Sloane in Jamaica, and by Kalm in Canada, all described or cited by Linnaeus, are in existence, those of Kalm and Browne in the Linnaean Herbarium at the rooms of the Linnaean Society at London, those of Sloane at the British Museum of Natural History.

Examples of Type Specimens

Panicum magnum Hitchc. Contr. U. S. Nat. Herb. **22** : 489. 1922. The type specimen is indicated as follows: " Type in the U. S. National Herbarium, No. 1,038,505, collected in rich soil along edge of forest about three miles southeast of Bartica, British Guiana, December 10, 1919, by A. S. Hitchcock (No. 17,194)." Several other specimens are cited at the same time.

Panicum Helleri Nash, Bull. Torrey Club **26** : 572. 1899. Nash does not indicate a type as such but he cites a single specimen with data as follows: " Collected at Kerrville, Kerr Co., Texas, by A. A. Heller, May 14–21, 1894, No. 1759." At that time Nash maintained a private herbarium (now a part of the herbarium of the New York Botanical Garden) and there was no difficulty in finding the specimen cited, which is the type. This specimen was one of a series or set, with printed labels, distributed to many herbaria. The whole series of specimens under the same number, collected at the same time and place, makes up the type collection; those other than the type are called duplicate types (the co-types of some botanists, though this term is used by some for specimens cited at the same time as the type).

Panicum neuranthum Griseb. Cat. Pl. Cub. 232. 1866. Charles Wright collected plants for several years in Cuba. His plants were made up into sets at the Gray Herbarium

and distributed to many herbaria. A preliminary set was sent to Grisebach for study and he published the results in his catalog of Cuban plants. The type specimens are in Grisebach's set, now at the University of Göttingen. The sets distributed to herbaria were for the most part numbered, but some specimens were sent out without number, bearing the year of collection. The article says concerning *Panicum neuranthum*, " Cuba or. (Wr. 3453); occ., in savanis pr. Hanabana (Wr. a. 1865: forma ascendens, ramosa, foliis planis, spiculis ut in α)." On consulting Grisebach's herbarium, one finds two specimens. The one from which the description is drawn and which is labeled *P. neuranthum*, was collected in eastern Cuba in 1860 and is numbered " 103–3453." The first number is the number of Grisebach's preliminary set and the second is the corresponding number of the distributed sets. A second specimen was collected in 1865 and is labeled " α forma ascendens ramosa." This specimen belongs to a different species, afterwards published as *P. chrysopsidifolium* Nash. There has been much confusion regarding *P. neuranthum* because both species were distributed under the number 3453. To add to the confusion, a third species (*P. fusiforme* Hitchc.) called by Grisebach *P. neuranthum ramosum*, based upon " Cuba occ. (Wr. 3454)," was mixed with the preceding. The result is that in different herbaria one finds under number 3453 the three species, singly or mixed. Only by an examination of the type specimen could the confusion be cleared up.

There are numerous cases where confusion has arisen as to the application of specific names because more than one species has been distributed under one number. In critical work a botanist should assure himself that any duplicate type he may have at hand is the same as the type, especially if there appears to be any discrepancy between specimen and description.

Panicum distantiflorum Rich. in Sagra, Hist. Cuba **11** : 304. 1850. The author states, after the description, con-

cerning the specimen, " Crescit in graminosis montosis insulae Cubae." This statement implies a single specimen which would be the type. In the Paris Herbarium is a specimen received from Sagra (the author of the " History of Cuba " in which Richard described the plants) and labeled " in montosis ins. Cubae." The specimen corresponds to the description and is the type. On a sheet of a very different species, from Cayenne, is a slip with a diagnosis and drawing, and also the name *Panicum distantiflorum*. This slip was evidently attached by mistake to the wrong sheet. It is mentioned here only to warn the student against being misled by errors. The mere finding of a specimen with a name attached does not establish a type. Many of the older collections were studied and handled unmounted, and labels might have been misplaced.

Panicum Chapmani Vasey, Bull. Torrey Club **11** : 61. 1884. Vasey describes the plant, citing no locality or specimen but stating, " This is the *Panicum tenuiculmum* of Chapman's Flora, but is not the *P. tenuiculmum* of Meyer." In the U. S. National Herbarium is a specimen from the Chapman Herbarium labeled in Chapman's hand, " *Panicum tenuiculmum* S. Fl. S. Florida " (that is, *P. tenuiculmum* of the Southern Flora from South Florida), and in Vasey's hand, " *Panicum Chapmani* Vasey." This specimen establishes the connection indicated by Vasey and is evidently the type of his species.

Panicum subspicatum Vasey, U. S. Dept. Agr. Div. Bot. Bull. **8** : 25. 1889. At the end of the description one finds merely " Texas (Buckley, Nealley)." Both the specimens cited are in the U. S. National Herbarium. The specimen collected by Nealley has the specific name in Vasey's handwriting and the one collected by Buckley has not. Furthermore, the Buckley specimen is a mixture of *P. subspicatum* and *P. Reverchoni*. Hence, the Nealley specimen is chosen as the type. Another Nealley specimen bears the name in Vasey's handwriting, but was collected in 1892, after the publication of the species. *Panicum subspicatum* Vasey

was invalidated by *P. subspicatum* Desv. (1831) and the name was changed by Scribner to *P. ramisetum*. As this is a substitution of one name for another, the Nealley specimen is also the type of *P. ramisetum*.

Panicum adspersum Trin. Gram. Pan. 146. 1826. The extreme degree to which abbreviation was practiced by some of the older authors is illustrated here. Trinius states concerning the origin of his specimen, " V. sp. Doming. (Sprengel, sub nomina Pan. caespitose.)" The type, in the Trinius Herbarium is labeled, " Panicum adspersum m. St. Domingense s. n. P. caespitosum Lam. (!) mis. cl. Sprengel." (m. = mihi; s. n. = sub nomine; mis. cl. Sprengel = sent by (the celebrated) Sprengel.)

Panicum dichotomiflorum Michx. Fl. Bor. Amer. **1**: 48. 1803. Michaux states concerning this, " Hab. in occidentalibus montium Alleghanis." The present writer sought the type of this species in the Michaux Herbarium, segregated in a special case in the Paris Herbarium. A specimen here was labeled " in regione Illinoensium." This was an authentic specimen but the locality did not agree with that published. Later a specimen was found in the Drake de Castillo Herbarium (then at the residence of Drake de Castillo in Paris, now a part of the Paris Herbarium) which was evidently the type. It was collected by Michaux, sent to Drake de Castillo by Richard (who prepared Michaux's flora), and was labeled " ad occidentum montium Alleghanis," thus agreeing with the published data.

Panicum capillare campestre Gattinger, Tenn. Fl. 94. 1887. No locality nor specimen is cited, but as the work cited is a flora of Tennessee the type must be from that state. In the Gattinger Herbarium are four specimens labeled in Gattinger's hand, " *Panicum capillare* L. var. *campestre* Gattinger." One of these was arbitrarily chosen as the type by Hitchcock and Chase in their revision of *Panicum*, the one bearing the data " Cedar glades near Nashville, Sept. A. Gattinger." On account of the earlier *Panicum campestre* Nees, Gattinger's variety could not be

raised to specific rank with the name campestre, and the name was changed by Nash to *P. Gattingeri*, the type remaining the same.

Panicum capillare L. Sp. Pl. 58. 1753. Linnaeus gives no description of his own but bases his name upon a phrase name of Gronovius (Fl. Virg. **1** : 13. 1739) which he quotes. Gronovius mentions one specimen, Clayton 454, which is the type of the Linnaean species. This specimen is at the British Museum of Natural History.

Panicum barbipulvinatum Nash in Rydb. Mem. N. Y. Bot. Gard. **1** : 21. 1900. Nash cites as synonym, *P. capillare brevifolium* Vasey, not *P. brevifolium* L., but he also gives a description and indicates a type, Rydberg & Bessey 3544 from Yellowstone Park. If there were no description the new name would be a substitute for the old and would have the same type. But with a description given, the indicated type from which the description was drawn must be accepted.

Panicum Hallii Vasey, Bull. Torrey Club **11** : 64. 1884. Vasey states that " this is number 816 of E. Hall's Texas Collection." There were two species distributed under this number. The specimen in the U. S. National Herbarium from which Vasey drew up the description and which bears the name in his handwriting is the type. The other species was subsequently named *P. filipes* by Scribner. This and similar cases emphasize the necessity of guarding against errors when collecting or distributing several specimens under one number.

Panicum Ghiesbreghtii Fourn. Mex. Pl. **2** : 29. 1886. Fournier cites three specimens, one of which was collected by Ghiesbreght and hence is the type.

Panicum depauperatum Muhl. Descr. Gram. 112. 1817. As Muhlenberg cites no definite specimen, merely saying that the species grows in Pennsylvania and Carolina, it is necessary to consult his herbarium, now at the Philadelphia Academy of Sciences, in order to determine the type. In the cover marked *P. depauperatum* are specimens of three

forms, one with smaller spikelets (*P. linearifolium*), and two with larger spikelets, one of which has glabrous sheaths and the other pubescent sheaths. A careful comparison shows that the last specimen accords best with the description and hence this was selected as the type and so marked in the herbarium.

Panicum barbulatum Michx. Fl. Bor. Amer. **1** : 49. 1803. Michaux gives Carolina as the locality. In the Michaux Herbarium at Paris are two specimens with bearded nodes and one not bearded (*P. Lindheimeri*) all said to be from Canada. In the Drake de Castillo Herbarium is a specimen of *P. Ashei*, labeled *P. barbulatum*, collected by Michaux in Carolina, and sent by Richard. There is conflict of evidence here. The description states that the nodes are pubescent or barbed (whence the name) which excludes the specimen of *P. Lindheimeri* and that of *P. Ashei*. Hence the specimens from Canada are chosen as the type. It would appear that the description was drawn from the Canada specimen with bearded nodes and the locality taken from the specimen sent by Richard.

Panicum Scribnerianum Nash, Bull. Torrey Club **22** : 421. 1895. The choosing of the type of this species illustrates the effect of conflicting evidence. Nash proposes the above name as new, giving as synonym " *Panicum scoparium* S. Wats. in A. Gray; Man. Ed. 6. 632. 1890. Not Lam. *Panicum scoparium* var. *minor* Scribn. Bull. Univ. Tenn. **7** : 48. 1894. Not *P. capillare* var. *minor* Muhl. 1817." The two synonyms represent two species. The subsequent descriptions of *P. Scribnerianum* by Nash show that he had in mind the species described by Watson in Gray's Manual. The specific name would indicate that he had in mind Scribner's *P. scoparium minor*. It is evident, however, that Nash was citing Scribner's name without knowing the form to which Scribner applied it (the smaller velvety species that Nash afterwards named *P. malacophyllum*). The common northeastern form described by Watson in Gray's " Manual " under the name *P. scoparium*, well known to

Nash, was clearly the form to which he wished to give a tenable name, "*P. scoparium*" being a misapplication. Hence the type of *P. Scribnerianum* is the specimen which is the basis of the description of *P. scoparium* in the sixth edition of Gray's "Manual." An examination of the various editions of Gray's "Manual" shows that the description of *P. scoparium* in the sixth is identical with the description of "*P. pauciflorum* Ell.?" in the other editions, back to the first where a specimen by Carey is mentioned. Therefore, the type of *P. Scribnerianum* is the Carey specimen in the Gray Herbarium collected at Wysox, Pennsylvania, by J. Carey in 1836.

It is interesting to note in this connection that *P. scoparium* as described by Elliott in his "Botany of South Carolina" is not the same as *P. scoparium* Lam. Scribner and Merrill, therefore, renamed this *P. Ravenelii*, of which Elliott's specimen is the type.

Panicum campestre Nees; Trin. Gram. Pan. 197. 1826. This was described by Trinius from a specimen collected in Brazil by Sellow. Three years later (Agrost. Bras. 197. 1829) Nees described under the name of *Panicum campestre* a different species collected by Martius. Trinius and Nees were in correspondence and Nees sent many specimens to Trinius. The latter described *P. campestre*, ascribing it to Nees, supposing it to be the same species that Nees had under that name. *Panicum campestre* Nees, as described by Trinius, is the valid species, while the species described by Nees himself must receive a different name. A botanist, in searching for the type of *P. campestre* Nees, would find in the Munich Herbarium the Martius specimen with the name in Nees' handwriting, and would be misled thereby if he did not seek further and compare the description published by Trinius and examine the type in the Trinius Herbarium.

Paspalum Pittieri Hack.; Beal Grasses N. Amer. **2** : 88. 1896. This name was first applied by Hackel to a species collected in Costa Rica by Pittier (No. 507) and the duplicates of this collection were distributed to many herbaria,

bearing this unpublished name. Scribner identified one of Pringle's Mexican grasses (No. 2359) as *P. Pittieri*, and this collection was also distributed. The Costa Rican and Mexican plants belonged to different species, however. Beal, in working over American grasses for his book, noting that *Paspalum Pittieri* was unpublished, described it and cited only one specimen, " Mexico, Pringle 2359." Later, Hackel published his *P. Pittieri* (Oesterr. Bot. Zeit. **51** : 234. 1901) citing Pittier's No. 507, not knowing that the name had been published by Beal. The unfortunate result is that *P. Pittieri* Hack., as published by Beal with the type Pringle 2359, a specimen not seen by Hackel, has precedence over *P. Pittieri* as published by Hackel himself, which is a different species.

The case is further complicated because *Paspalum Pittieri* as published by Beal is the same as *P. clavuliferum*, an earlier name, while the Costa Rican species had no tenable name until Ekman published *P. pictum* for the species, the type being from South America.

CHAPTER XV

CODES OF NOMENCLATURE

It is only within the last three or four hundred years that books have been devoted to the description of plants. The earlier works published within this period, usually known as herbals, were, from the modern standpoint, very crude in their method of presentation. There has been a gradual evolution in classification and nomenclature. Species were first looked upon merely as kinds of plants, without much conception of relationships. Later, certain related species, such as the oaks and the maples, in which the affinities were especially obvious, were recognized as groups. The concept of genera as a system in taxonomy with a corresponding generic nomenclature, dates from the publication of Tournefort's "Institutiones Rei Herbariae," in 1700. Generic names were here consistently applied to groups of related species. The species themselves were indicated by short Latin descriptions, sometimes referred to as polynomials, more accurately as phrase names. The following example from this work will illustrate how species were listed. After describing the genus *Hordeum*, Tournefort says the species of *Hordeum* are:

Hordeum polystichum, Hybernum [of Bauhin].

Hordeum polystichum, vernum [of Bauhin].

Hordeum distichon, quod spica binos ordines habeat [of Bauhin].

Hordeum distichum, spica breviore & latiore, granis confertis [of Ray].

Hordeum distichum, spica nitida, Zea seu Briza nuncupatum.

This method of citing species was cumbersome. A great advance was made when Linnaeus introduced binomial

nomenclature in his epoch-making work, the "Species Plantarum," published in 1753. Here he assigned to each species a single name, called by him the trivial name but later known as the specific name. This system placed nomenclature upon a sound basis. Every species was assigned to a genus; the name of the plant was the binomial, the combination of the generic and specific names. No two genera could bear the same name; no two species in the same genus could bear the same name. The introduction of this system gave a great impetus to systematic botany. There followed an era of exploration in which large numbers of new plants were brought to light. Hundreds of new species were described and the number of genera greatly increased. In a general way, priority of publication was recognized, and in a conflict between two names applying to the same species but published at different dates there was a tendency to use the earlier name. The number of known species was growing so rapidly that confusion in nomenclature arose. For various reasons the botanists of one country did not always keep themselves informed of what was being done in another country. National and personal jealousies occasionally had their influence in suppressing published names. Certain botanists, through the weight of their influence, often dominated the taxonomic field in their respective countries. The names used in important taxonomic works gained the ascendency, at least for a time. The need for generally recognized and accepted rules of nomenclature became apparent. Individual botanists from time to time proposed rules, but the first general movement took place at the International Botanical Congress which met at Paris in 1867. This Congress formulated a set of rules, or Laws of Nomenclature, which crystallized the consensus of botanical opinion prevailing at that time. The experience gained in applying these rules gradually brought out their deficiencies. In the main, the rules had proved their value, but it became increasingly evident that modifications were needed.

The next effort by an international body to formulate rules was made by the International Congress which met at Vienna in 1905. This Congress formulated a code known as the International Rules of Botanical Nomenclature. These rules were based upon the Paris Code, but included many important modifications.

Meantime, in the United States, there arose a group of taxonomists who wished to develop a set of rules which they thought would place our nomenclature upon a much surer foundation as compared with the old Paris Code. The movement involved, first, the concept of types as a system for directing the application of names, and second, the strict application of the laws of priority. It was believed that while the application of such a system would necessitate a considerable number of changes of plant names, the nomenclature would finally be more stable.

The result of this movement to introduce new rules was the code published in 1904 (Bull. Torrey Club **31** : 249) and modified in 1907 (op. cit. **34** : 167), which came to be called the American Code. This code was presented for consideration to the Vienna Congress. While it may have had some influence in modifying the International Rules, its main features were rejected. Many of the botanists who had supported the American Code refused to accept the International Rules — usually known in this country as the Vienna Code — and continued to work under the code to which they had become accustomed and which they felt was founded upon such logical principles that it must in the main ultimately prevail.

Several years' trial with both codes brought to light weaknesses in each, and there was desire for modifications. In 1920 a new code, called the Type-basis Code, was prepared by the Committee on Nomenclature of the Botanical Society of America.[1] This code included the principles of

[1] This code was presented as a report of progress and was not acted upon by the Society.

the American Code but introduced more flexibility to meet unforeseen circumstances.

The zoölogists have the International Code of Zoölogical Nomenclature, the ornithologists their code of nomenclature adopted by the American Ornithologists' Union, and the entomologists the Entomological Code prepared by Banks and Caudell. The rules of these codes are similar to those included in the American Code of Botanical Nomenclature.

A code of nomenclature is a set of rules to aid biologists in applying names by which groups are designated in classification. Such rules have authority only through a consensus of opinion among taxonomic biologists. They represent this consensus of opinion just as do rules or codes in any other branch of human activity. A code, therefore, represents agreement among those who formulated its provisions. While dominating personalities may, through their influence, mold a code according to their wishes, the code in order to continue as a guide must be intrinsically acceptable to users. These considerations were clearly set forth in the first two articles of the Paris Code (1867) previously mentioned.

ARTICLE 1. — Natural History can make no real progress without a regular system of nomenclature, acknowledged and used by a large majority of naturalists of all countries.

ARTICLE 2. — The rules of nomenclature should neither be arbitrary nor imposed by authority. They must be founded on considerations clear and forcible enough for everyone to comprehend and be disposed to accept.

The student of taxonomy should become familiar with the four important botanical codes, known conventionally as the Paris Code, the Vienna Code, the American Code, and the Type-basis Code. Brief outlines of these follow.

The Paris Code

Laws of Botanical Nomenclature adopted by the International Botanical Congress held at Paris in August, 1867.

The dominating influence in the formulation of this code

was that of Alphonse de Candolle, who drew up the document for consideration by the Congress.

The code consists of 68 articles followed by a rather extensive commentary or explanation. Articles 1 to 7 present general principles; articles 8 to 14 describe the kinds of groups in classification and give the name by which each is designated; articles 15 to 40 give in detail the manner in which the names of the groups are formed; articles 41 to 47 concern the publication of names; articles 48 to 52 concern the manner of indicating the authority for names of groups. Up to this point the code contains only provisions to which botanists in general subscribe. Articles 53 to 58 deal with names to be retained when changes in rank of groups are made; and articles 59 to 64 deal with the rejection of names. Here are rules which are of vital importance in establishing a stable nomenclature. These rules are as follows:

Article 53. An alteration of characters or a revision carrying with it the exclusion of certain elements of a group, or the addition of fresh ones, does not warrant a change in the name or names of a group.

Article 54. When a genus is divided into two or more genera, its name must be retained and given to one of the chief divisions. If the genus contains a section or some other division, which, judging by its name or by its species, is the type or origin of the group, the name is reserved for that part of it. If there is no such section or subdivision, but one of the parts detached contains, however, a great many more species than the other, it is to that part that the original name is to be applied.

Article 55. In case two or more groups of the same nature are united into one, the name of the oldest is preserved. If the names are of the same date, the author chooses.

Article 56. When a species is divided into two or more species, if one of the forms happens to have been distinguished earlier than the others, the name is retained for that form.

Article 57. When a section or a species is moved into another genus, or when a variety or some other division of a species is given as such to another species, the name of the section, the specific name or that of the division of the species is maintained, unless there arise one of the obstacles mentioned in Articles 62 and 63.

Article 58. When a tribe is made into an order, when a subgenus or a section becomes a genus, or when a division of a species becomes a species, or vice versa, the old names are maintained, provided the result be not the existence of two genera of the same name in the Vegetable Kingdom, two divisions of a genus, or two species of the same name in the same genus, or two divisions of the same name in the same species.

Article 59. Nobody is authorized to change a name because it is badly chosen or disagreeable, or because another is preferable or better known, or for any other motive, either contestable or of little import.

Article 60. Everyone is bound to reject a name in the following cases:

(1) When a name is applied, in the Vegetable Kingdom, to a group that has before received a name in due form.

(2) When it is already in use for a class or for a genus, or is applied to a division, or to a species of the same genus, or to a subdivision of the same species.

(3) When it expresses a character or an attribute that is positively wanting in the whole of the group in question, or at least in the greater part of the elements of which it is composed.

(4) When it is formed by the combination of two languages.

(5) When it is in opposition to the rules laid down in Section 5 [Articles 53–58].

Article 61. The name of a cohort, subcohort, order, suborder, tribe or subtribe, must be changed if taken from a genus found not to belong to the group in question.

Article 62. When a subgenus, a section, or a subsection passes as such into another genus, the name must be changed if there is already, in that genus, a group of the same rank, under the same name.

When a species is moved from one genus into another, its specific name must be changed if it is already borne by one of the species of that genus. So, likewise, when a subspecies, a variety, or some other subdivision of a species is placed under another species, its name must be changed if borne already by a form of like rank in that species.

Article 63. When a group is transferred to another, keeping there the same rank, its name will have to be changed if it leads to misconception.

Article 64. In the cases foreseen in Articles 60, 61, 62, 63, the name to be rejected or changed is replaced by the oldest admissible one existing for the group in question; in the absence of this, a new one is to be made.

Article 65 concerns names above the genus; Article 66, the correction of badly formed names; Article 67, the desirability of using Latin names; Article 68, the avoidance of names not derived from Latin.

The Vienna Code

International rules of botanical nomenclature adopted by the International Botanical Congress of Vienna, 1905.

These rules are based on the Paris Code but considerably modified and amplified. There are 58 articles. The prescriptions governing nomenclature are divided into principles, rules and recommendations. Articles 1 and 2 of the Paris Code (noted above on page 154) are repeated, as are several others. The more important modifications or additions are mentioned below.

In the Paris Code the principle of priority was included in Article 15 as follows: Each natural group of plants can bear in Science but one valid designation, namely, the most ancient, whether adopted by Linnaeus, or since Linnaeus, provided it be consistent with the essential rules of nomen-

clature. This in a slightly modified form appears in the Vienna Code (Art. 15) but is modified by Article 19, which says: " Botanical nomenclature begins with the ' Species Plantarum ' of Linnaeus, ed. 1 (1753) for all groups of vascular plants." It is agreed to associate genera, the names of which appear in this work, with the descriptions given of them in the " Genera Plantarum," fifth edition (1754).

Article 20 contains the following reference to *nomina conservanda*: " However, to avoid disadvantageous changes in the nomenclature of genera by the strict application of the rules of Nomenclature, and especially of the principle of priority in starting from 1753, the rules provide a list of names which must be retained in all cases. These names are by preference those which have come into general use in the fifty years following their publication, or which have been used in monographs and important floristic (floristiques) works up to the year 1890. The list of these names forms an appendix to the Rules of Nomenclature.

Under section 4, on the publication of names, the following rule is of interest:

Article 36. On and after January 1, 1908, the publication of names of new groups will be valid only when they are accompanied by a Latin diagnosis.

The series of rules concerning the names to be used when groups are united, separated, or transferred (Art. 53–58 of Paris Code; Art. 44–49 of Vienna Code) are essentially the same in the two codes.

Article 50. No one is authorized to reject a name . . . because of the existence of an earlier homonym which is universally regarded as non-valid. This is an important modification of Article 59 of the Paris Code and constitutes one of the prominent differences between the American and Vienna Codes.

Article 53 includes the statement " When a species is moved from one genus into another, its specific epithet must be changed if it is already borne by a valid species of that

genus." This is an important modification of Article 57 of the Paris Code.

In Article 55 of the Vienna Code, duplicate binomials are disposed of thus: "Specific names must be rejected when they merely repeat the generic names."

Finally, Article 58, the last one, is somewhat controversial. It says that the rules of botanical nomenclature can only be modified by competent persons at an international congress convened for that express purpose. Some have asserted this to mean that the present rules can legally only be amplified but can not be fundamentally changed. Others interpret the rule to mean that a properly constituted congress can change the rules in any way that it sees fit.

In 1910, another International Botanical Congress met at Brussels and made some minor changes in the rules of nomenclature.

Article 19 was amended so as to legalize different starting dates for nomenclature in different groups of Cryptogams.

An important recommendation was added to Article 30: "When publishing names of new groups, one should indicate carefully the subdivision which one considers the nomenclatorial type of the group: the type genus of a family; the type species of a genus; the type variety or type specimen of a species. This precaution will avoid the nomenclatorial difficulties where, in the future, the group is to be divided." This recommendation is the first recognition of the type concept.

Appended to the Code is a list of conserved names, names which shall be conserved even though there are earlier synonyms (see Article 20).

The American Code

A Nomenclature Commission was appointed by the Botanical Club of the American Association for the Advancement of Science at a meeting held in Washington, D. C., January 2, 1903. This Commission prepared a code

for presentation to the International Congress that was to meet in Vienna in 1905. It considered modifying the Paris Code of 1867 but finally decided to formulate an entirely new code. The code, called a Code of Botanical Nomenclature, was printed in the Bulletin of the Torrey Botanical Club.[1]

The Code is divided into Principles and Canons. The Principles are of sufficient importance to be quoted:

1. The primary object of formal nomenclature in systematic biology is to secure stability, uniformity and convenience in the designation of plants and animals.

2. Botanical nomenclature is treated as beginning with the general application of binomial names of plants (Linnaeus' " Species Plantarum," 1753).

3. Priority of publication is a fundamental principle of botanical nomenclature. Two groups of the same category can not bear the same name.

Note. — Previous use of a name in zoölogy does not preclude its use in botany.

4. The application of a name is determined by reference to its nomenclatorial type.

Priority of publication was recognized, at least by inference, in the Paris and Vienna codes, but the American Code sets it forth as a fundamental principle.

Principle 4 of the American Code announces the Type Concept. This concept, which was entirely ignored in the preceding codes, is the really outstanding contribution of the American Code to botanical nomenclature.

Canons 1–8 concern categories of classification and formation of names; canons 9–13, the publication of names; canons 14 and 15, the application of names; canons 16–19, the rejection of names. The arrangement of the code is more logical and more concise than that of the Paris or Vienna codes.

The above code was presented at the Vienna Congress

[1] Bull. Torrey Club **31** : 249. 1904.

but was rejected. In view of agreements reached at the Vienna Congress, the Nomenclature Commission which had formulated the American Code decided to revise it. The revised code was published under the name of the " American Code of Botanical Nomenclature."[1] Thè arrangement and number of the canons is the same as in the earlier edition, but there are some modifications in the wording and in the scope of the canons.

The outstanding features are as follows:

The principle of priority definitely stated.

The concept of types as controlling the application of names.

A generic name is published (among other ways) when accompanied by a specific description and a binomial specific name.

Priority of position: Of names published in the same work and at the same time, those having precedence of position are to be regarded as having priority (Canon 13).

The rules for selecting (retroactively) the type species of genera and the type specimens of species.

A name is invalidated by an earlier homonym even though the latter may not be valid (Canon 16).

The earliest generic name is used; there is no list of *nomina conservanda.*

The Type-basis Code

More recently, the Committee on Nomenclature of the Botanical Society of America formulated a new code based upon the American Code but containing important modifications which allowed much greater flexibility in its use. This code was called the Type-basis Code of Botanical Nomenclature. As this represents the most recent consensus of opinion among those taxonomic botanists in America who accept the type concept, it is reproduced in full in the Appendix.

[1] Bull. Torrey Club **34** : 167–178. **1907.**

This code differs from the American Code in many minor details, and in one important respect, the inclusion of an article (Art. 7) providing that there may be exceptions to the rules if these exceptions can be agreed upon.

Chief Differences between the Type-basis Code and the International Rules

1. The most important feature of the Type-basis Code is the type concept — the application of names by means of types. This is ignored in the International Rules [referred to below as the "Rules"]. At the Brussels Congress, a recommendation was added providing for the designation of types in the future. The type concept of the Type-basis Code is not contrary to the International Rules.

2. The Type-basis Code adopts 1753 as the starting point for nomenclature of all groups of plants. The Rules adopt 1753 for vascular plants and for some groups of Cryptogams, and later dates for certain other groups of Cryptogams. If the type concept were introduced into the Rules, the need for later starting points for certain groups would not be felt to the same degree by the followers of those rules.

3. Priority of publication is accepted as a fundamental principle by both codes. The Rules, in order to retain well-known generic names in their current usage, arbitrarily conserve certain of these even though they would be rejected under the priority rule. These conserved names are brought together in a list appended to the Rules. This is the list of *Nomina Conservanda*. The Type-basis Code includes no such list. It is recognized, however, that the strict application of the law of priority may in a few cases cause inconvenience by displacing well-known names. Article 7 provides for exceptions. Ultimately there may be a short list of *nomina conservanda* attached to the Type-basis Code if in the opinion of its followers such a list is desirable.

4. The Type-basis Code provides that a generic name is effectively published when there is a specific description

and a binomial specific name. The Rules do not admit effective publication in such a case. The attitude of the Code is influenced by the Type Concept. Publication of the kind mentioned is effective because the proposed genus is connected with one or more species and its type species may be determined.

5. The Rules provide that a genus is effectively published when there is a generic description without the mention of included species. The Type-basis Code considers such publication to be ineffective because it is impossible to determine the type species of the proposed genus.

6. The Type-basis Code provides that " Of names published in the same work and at the same time, those having precedence of position are to be regarded as having priority." This has been referred to as priority of position. The Rules provide, instead, that such names have equal standing.

7. The Type-basis Code provides that both generic and specific names are to be rejected if there are earlier homonyms, regardless of the standing of these homonyms. The Rules provide that a name shall not be rejected " because of the existence of an earlier homonym which is universally regarded as non-valid." In practice, this requires the investigation of the standing of the earlier homonym, often in groups with which the investigator is unfamiliar, and is obviously unsatisfactory. Under the Rules, if the earlier homonym is a synonym, the later name may stand. Few will take the time to conduct an investigation as to the standing of the synonym; instead, they are likely to accept the statements of others.

As a result of the provision quoted from the Rules in the preceding paragraph, another article of the Rules provides that " When a species is moved from one genus to another, its specific epithet must be changed if it is already borne by a valid species of that genus." If the earlier homonym is a synonym, the transferred name can stand. The Type-basis Code, on the contrary, holds that the later homonym is always invalid.

8. The Rules reject a specific name when it repeats the generic name. Names of this sort, such as *Phragmites Phragmites*, have been called duplicate binomials. The Type-basis Code admits no exception to the law of priority because of the identity of the generic and specific names.

9. The Rules provide that, after January 1, 1908, effective publication of genera, species and other groups of plants, shall require the diagnosis to be in Latin.

An analysis of these differences shows that (1), (2), (4) and (5) concern the type concept. This concept is making such headway among botanists of the world, including the followers of the Rules, that it probably will be formally adopted in the near future, especially as the concept is not contrary to the present provisions of the Rules. If this is adopted, the other differences in this connection (the other three of the four mentioned) can be easily compromised.

The differences mentioned under (3) the *nomina conservanda*, (6) priority of position, and (8) duplicate binomials are not of fundamental importance and probably could be compromised. The advocates of the Type-basis Code are not strongly in favor of duplicate binomials, nor are they, for the most part, in favor of rejecting well-known names merely to satisfy "priority of position." Many of these advocates, including the present author, have no inherent objection to conserved generic names. They wish, however, that the number may be kept low and consider the present list of *nomina conservanda* to be entirely too long. Furthermore, they think that the list was not sufficiently considered before its adoption.

The seventh difference mentioned above, the validity of homonyms, may not be easily reconciled. Those who have used the American Code in times past find its provisions in regard to this so convenient and so definite that they will scarcely give them up for the vague and unsatisfactory provisions of the Rules.

As to difference number (9), it is probable that the provision will be eliminated from the Rules because of a general

objection to its limitations. It is not a matter that need seriously concern those who wish to bring about a compromise.

It would appear that the followers of the Rules have judged the American Code largely upon three points, the refusal of its advocates to adopt the list of *nomina conservanda*, the freak workings of the law of priority of position, and the curious appearance of duplicate binomials. These points are of minor importance. Fundamentally, the type concept is the important point in the American Code and in the Type-basis Code. If the three points mentioned were modified or eliminated, much of the objection to the Type-basis Code would disappear.

CHAPTER XVI

THE GRASS HERBARIUM

Officially, the Grass Herbarium is the section of grasses in the Division of Plants (commonly known as the United States National Herbarium), United States National Museum. The following description of the equipment and facilities may be helpful to those planning to study a special group of plants.

Herbarium

The mounted specimens of grasses number about 150,000, included in 100 unit cases (each with 24 standard compartments 6 inches high). The specimens are mounted on standard herbarium paper (11½ by 16½ inches) and are contained in genus covers of medium weight. The genera are arranged according to Dalla Torre and Harms' " Index Siphonogomarum," with the exception of the Paniceae which are in accord with Chase's " Genera Paniceae " (see Proc. Biol. Soc. Washington **24** : 103–159. 1911).

The arrangement of the covers within each genus, to indicate major geographical areas, is as follows: ordinary, standard-weight manila genus covers are used for specimens from the United States and northward, each species having at least one cover; the specimens from the West Indies are in blue covers; from Mexico and south to Panama, in red covers; from South America, in yellow covers; from Asia, including the Philippines and the East Indies, in green covers; from Europe, in gray covers; from Africa, in chocolate-colored covers; from Australia and New Zealand, in orange covers. Because especial attention has been given to the grasses of the Hawaiian Islands, these are in manila covers with a large triangle of violet on the right-hand corner. Manila covers similarly marked with green contain grasses

cultivated in the United States, especially those tested at experiment stations. The color scheme has been gradually developed as a matter of convenience during the progress of the work.

For the present, the grasses in covers other than plain manila have one cover devoted to a single species only when there are enough sheets to fill it moderately. These have the species name written in the lower right-hand corner, the name of the genus, with its index number, being in the lower left-hand corner, printed with movable rubber type. When there are not enough sheets of a single species to fill a genus cover, the species are placed in light manila covers and these combined in suitable number to fill a cover. As the number of sheets increases, they are placed in individual genus covers as soon as there are sufficient to warrant the change. When covers become more than about 2 inches thick, the contents are divided.

The specimens in the manila covers are so numerous that further subdivision is practicable. When the sheets of a single species occupy more than one cover, a geographical segregation is made. The sheets of *Andropogon scoparius*, for example, occupy several compartments in the cases. They are arranged by states or groups of states, according to the list of states given in the Century Atlas, the names of the states being written on the covers at the center of the lower margin.

Originally, the arrangement of the species was alphabetical. In the manila covers this has been replaced by a systematic arrangement. Manuscript keys have been prepared in triplicate to the species of the genera in the United States. One copy is in the book of keys (held in a spring-back binder), one copy in the working collection (to be described later) and one copy in a cover at the beginning of each genus in the general collection. The species are arranged in the herbarium according to the key, and correspondingly numbered. An alphabetical index accompanies each of the larger keys.

The type specimens are segregated in separate cases. They are thus more accessible for consultation during the preparation of critical revisions, and they escape the wear incident to the usual handling to which they would be subjected in the general herbarium. The collection includes not only type specimens but also duplicate types (in the absence of types), fragments of types contributed by other herbaria, photographs of types, and notes, drawings, and other data bearing upon the types. The specimens are arranged systematically according to the valid specific name. A card index enables one to find the types under the accepted name.

For convenience, there is a working collection in which there is a representative specimen of every species in the United States. The larger genera are accompanied by keys to the species (one of the copies mentioned on page 167), and the specimens are numbered and arranged according to the keys. This serves for quick consultation in routine identification.

Miscellaneous duplicates are arranged in special cases in genus and species covers in the same sequence as that of the herbarium. Duplicate specimens are distributed into these covers and can be supplied in selected lots in exchange. Besides the main supply of duplicates, there are special lots that await critical study, such as those from expeditions to South American countries. These can not be distributed until the originals are identified. All duplicates in the main supply are identified and fully labeled before being sent out.

A special series of numbered sets of North American Grasses is being distributed to the larger herbaria of the world. Thirty sets of these have been prepared, and eight centuries have been issued. These are sent out as an exchange for grasses. In the main these sets support revisions of genera and floras of areas as they are published, and a large number are now awaiting monographic work. In addition to these sets two other special sets have been dis-

tributed; one, containing 122 numbers, to illustrate the Grasses of British Guiana (Contr. U. S. Nat. Herb. **22**: 439–515. 1922); the other, containing 66 numbers, to illustrate the Grasses of Hawaii (Mem. Bishop Mus. **8**: 101–230. 1922).

Library

There are in Washington several large libraries containing botanical works, the library of the United States Department of Agriculture, the library of the Smithsonian Institution, and the Library of Congress being the most important. The staff of the Grass Herbarium has access to these libraries, as do all the botanists in Washington connected with Government work. Because of the number of workers and the scattered location of the libraries, there is more or less delay in obtaining books, and an interval of one to several days may elapse between the request for a book and its receipt. As a matter of convenience, the Systematic Agrostologist and his assistant have built up a private library of works on agrostology. This consists primarily of books and pamphlets on grasses, including various editions of such works as Linnaeus' " Genera Plantarum" and Gray's " Manual of Botany." Of works in several volumes, such as the " Nova Genera " (H. B. K. Nov. Gen. & Sp.), " Flora of India " (Hook. Fl. Ind.), " Flora of Brazil " (Mart. Fl. Bras.), " Flora of Tropical Africa," " Flora Capensis," and " Flora Australiensis," it has been possible in many cases to obtain the portion devoted to grasses. Many of the pamphlets are authors' separates.

A large number of papers are found in journals and serials. Many of these are represented in the agrostologist's library by authors' separates or by the individual number of the periodical containing the desired article, and occasionally by the entire volume of the periodical. But there remains a large number of articles on systematic agrostology which can not be obtained in this way. These, in a great many cases, have been copied, either in manu-

script or by photography. Rare works in European libraries have been utilized in this way by the owners of this library while visiting the foreign institutions. In some cases, articles of several pages have been copied with a kodak, the prints being so small that a magnifying glass is necessary for reading them, but the record is definite. Circumstances of time and place have sometimes necessitated this method of copying when it has not been practicable to use a large camera. A very high percentage of the references to new species of grasses can thus be obtained in this private library without the delay incident to consulting the large libraries of Washington.

The books and pamphlets are arranged alphabetically according to authors, except that some of the pamphlets and many of the manuscripts and photographic copies are bound together. There is a complete index to all the papers, with an indication of their place in case they are not in the alphabetical position on the shelves.

Indexes

These labor-saving devices are of great importance and are freely used.

The leading card index is that to the original place of publication of new species and varieties. It serves the same purpose as the " Index Kewensis " but is more complete. The cards are 4 by 6 inches in size and are of rather light weight. The index was begun twenty-five years ago by Scribner and Merrill, when they copied the grass references in the " Index Kewensis " on cards. Additions are made directly from current literature and are checked up from the supplements to the " Index Kewensis " as they appear and from abstracting journals. The older literature has been gone over for varieties and other subdivisions of species, as these are not included in the " Index Kewensis."

Each card presents the bibliographic reference, including the year of publication and, in addition, data copied verbatim concerning the type. The cards also serve as a place

to record relevant statements, such as synonymy or bibliographic notes. Among the items recorded would be references to homonyms, such as, *Alpha alba* Smith 1870, not Jones 1850, and, when a species has been renamed, *Beta nigra* based on this. All the references have been verified from the original, except for a very small percentage where the original is inaccessible. Two examples from this index are given below:

Stipa pubescens R. Br. Prodr. Nov. Holl. 174. 1810.

"Apud Portum Jackson [Australia], inclusis ripis aestuarii Hunter's River vel Coal River."

Stipa oligostachya Hughes, Kew Bull. Misc. Inf. 1921: 12, figs. 7, 7A. 1921.

"Victoria [Australia]. Wendu Vale, growing in tussocks, Robertson 534*."

A supplementary index contains references to new genera. On these cards are given the data bearing on the type species, such as the number of species included.

Geographical Index. — In monographic or critical floristic work, it is important to know what species have been described from the area studied. To aid in working out synonymy, the published names in the larger genera are being classified on cards according to the country from which they were described. There will be brought together, for instance, all the proposed species of *Paspalum* described from Brazil.

Index to Abbreviations. — On cards (3 by 5 inches) are listed the abbreviations of titles and authors' names used in the Contributions from the U. S. National Herbarium. These serve as the standard in preparing manuscript for publication, and all manuscripts received from outside contributors are corrected by this list. The principles governing the form of abbreviation and a large original list were considered and decided upon by a committee, and additions, where authorized by the committee, are inserted in the index. In an Appendix to the present work (page 196) are given the rules for abbreviating titles and authors' names.

Economic Index. — Here are recorded notes on the economic botany of the grasses, more especially economic uses, common names and botanical notes. No attempt is made to include cultural notes as this belongs to the Office of Forage Crop Investigations.

Index to Numbered Specimens. — This consists of a series of cards, 4 by 6 inches, bearing consecutive numbers from 1 to 10,000. Upon these cards are recorded the names corresponding respectively to the numbers for the collectors of numbered series from North America. No attempt is made to keep this index up to date; consequently it can not be depended upon for entire accuracy. Corrected errors in identification are not recorded on these cards with any regularity, as this would consume time out of proportion to its usefulness. Nevertheless, the index is useful in determining whether there is in the herbarium a given number of a given collector, and the record indicates, at least approximately, the identity.

Miscellaneous

The collection of drawings has considerable historic interest as it includes the originals of cuts in the series of Bulletins of the Division of Agrostology, with all the data concerning the original specimens from which the drawings were made, so far as these have been recorded. The drawings are arranged in genus covers, systematically.

An herbarium index on note paper in a spring-back binder contains systematic and alphabetic indexes to the genera in the herbarium. It is based upon Dalla Torre and Harms' "Index Siphonogamarum," but is kept up to date by including additions and corrections as published. The Paniceae are arranged according to Chase's "Genera Paniceae," the series of numbers being independent and preceded by V (Tribe 5), thus, V13 *Syntherisma*.

For certain genera, such as *Muhlenbergia* and *Poa*, special

keys have been prepared in manuscript for office use. Corrections and additions are recorded upon these.

A manuscript list of the species and varieties of grasses in the United States, with the authority for each, is useful for routine consultation.

CHAPTER XVII

TRAVELING IN TROPICAL AMERICA

A few travel suggestions, based upon personal experience, may be helpful to those contemplating a trip to the countries to the south of the United States.

One should find out as much as possible about the country to be visited. It is well to consult books of travel, guide-books, Government yearbooks, geographies, and any other books or articles that give information on the general region concerned. The botanist wishes to obtain information on the following points:

Climate, especially the amount and distribution of rainfall;

Topography and physical geography generally;

Ecological distribution of plants, such as the forested areas, grass-covered areas, deserts, alpine meadows;

Means of communication — railroads, steamer lines, wagon roads, trails;

Customs of the people, money, language spoken, health conditions;

Resident scientists, public or private herbaria, government officials who may be able to give information or aid;

Regulations concerning travel, such as passports, customs duties, permits to enter or leave, certificate of vaccination.

The bibliography of works bearing upon these subjects is very extensive. Below are given a few representative or suggestive titles:

Spruce. Notes of a botanist on the Amazon and Andes.

Bingham. The journal of an expedition across Venezuela and Colombia.

Bowman. Desert trails of Atacama.

Roth. Richard Schomburgk's travels in British Guiana.

Terry's Mexico. Handbook for travelers.

Aspinall. The pocket guide to the West Indies, British Guiana, British Honduras, the Bermudas, the Spanish Main and the Panama Canal.

Ober. A guide to the West Indies and Bermudas.

The British Guiana handbook.

The handbook of Jamaica.

Register of Porto Rico.

Wolf. Geografía y geología del Ecuador.

Department of Commerce. Commercial travelers' guide to Latin America.

Department of Commerce. A series of bulletins dealing with trade conditions. Often containing in the introduction valuable data for travelers. For example, Miscellaneous series 69, Wearing Apparel in Bolivia, has several pages on natural divisions of the country, climate, trade routes and transportation facilities. A catalog of these publications may be obtained from the Department of Commerce.

Neumayer. Anleitung zu wissenschaftlichen Beobachtungen auf Reisen. Much technical information for professional travelers. Chapters on plants by Wittmack, Ascherson, Schweinfurth, Drude and others.

Hann. Handbuch der Klimatologie.

Weberbauer. Die Pflanzenwelt der peruanischen Anden.

Atlas América Latina. Valuable general information on each country, and good maps.

Usually the maps of a country can be obtained more satisfactorily in the country itself. Hence it is not advisable to burden oneself too much with maps before leaving this country.

In regard to climate, it is advisable first to consult Hann's work cited above. If a Government handbook of the country is accessible (such as the one for British Guiana, cited above) the details can be obtained there. In the absence of records in available books, it is recommended

that one write to the Weather Bureau of the United States Department of Agriculture for references to the data desired.

Letters of introduction are essential. If one goes in an official capacity, he secures a general letter from the Government or from the institution with which he is connected. It is well to obtain a general letter from the embassies or legations in Washington of the countries one wishes to visit, and in the language of these countries. At the same time it is advisable to get, if possible, a letter from these representatives to the customs officials of their country, explaining that the work is in the interest of science and not of a commercial nature. Such letters will usually permit the traveler to pass over a border without paying customs duties. Personal letters to friends, to institutions, or to industrial concerns are very helpful. After one reaches a country it is advisable to obtain an official letter from the Government for use when traveling in remote regions. This letter, in the language of the country, will explain the bearer's business and will allay suspicion. One should always carry his credentials with him when traveling, as a failure to do this may cause serious embarrassment.

Before leaving this country, it is necessary to obtain a passport and to have this viséd for the countries to be visited. One should also take with him a vaccination certificate. Passport and certificate are examined before one is allowed to enter a country. One finds that in some countries permits are required for departure (e.g., Ecuador).

The cost of a trip should be carefully estimated when deciding upon funds to be carried. If the currency of a country is depreciated, the cost of living there is likely to be lower than here. If one has time he can obtain information on cost of living and of transportation from our official representatives. Where there is an American Consul, he will give this information. Funds may be carried as cash or credit. American bank notes, especially gold certificates,

are acceptable in all the larger cities. Gold is always acceptable but is too heavy to carry in large quantities. Most travelers carry funds in some form of credit, of which the common forms are letter of credit, American express checks, American Bankers Association checks, and Cook's traveler's checks. The present writer has found it advantageous to carry funds of three forms, the largest amount in a letter of credit, $200 in traveler's checks of one of the three forms mentioned (in amounts of $20 and $50), and $200 in gold certificates (bills of $20). Before entering a country it is very desirable to have a few dollars' worth of the money of that country. The traveler should know in advance the accepted rate of exchange at the banks so that he may not be defrauded in making change at the border.

The equipment to carry on a journey should be a subject for careful consideration. The weight of baggage should be brought to a minimum and should include only articles essential for comfort and for the performance of the work to be done. The collecting outfit has been described in a preceding chapter (page 57). For work abroad this outfit must be modified to suit conditions. Sufficient driers and inner sheets should be taken from home for the entire trip, as supplies of this sort are difficult to obtain when needed. The main supply can be left at some convenient city while excursions are being made.

In selecting clothes, one should take into consideration the climate of the country to be visited, light clothing for the hot lowlands, heavier clothing for mountain regions. One takes with him about the same kind of clothing that he would use at home for the same climate.

If one expects to travel on mule back while abroad, there are certain additional pieces of equipment that are to be recommended. It is very desirable to take a saddle with one from this country. The foreign saddles are often uncomfortable, and even were this not so the changing of saddles as one changes mules is to be avoided. It is well also to

take a full-size horse blanket for a saddle blanket. In addition to its being easier on the animal, it is a fine emergency blanket for oneself. For his own work the author has used a McClellan army saddle (11-inch seat) and prefers the broad, leather-fronted wood stirrups used on cowboy saddles. In mountain regions where there is much going up and down, it is desirable to have the saddle provided with two cinches, one at front and one at back. These prevent the saddle from shifting. It is not necessary to carry a bridle from home, as the animals are accustomed to the foreign bridles. In addition to the articles mentioned, there should be good saddlebags and straps on the saddle to carry small articles. At the rear one carries a garment for protection against rain. For this purpose the author prefers a waterproof poncho. It is easy to put on while on the mule and it is suitable for additional bed covering when needed. One should provide oneself with spurs as the animals are usually accustomed to these and are very slow without them. It is well also to have a good leather whip. In urging an animal constantly with spurs there is danger of causing sores, so the spur is alternated with the whip. The saddle and equipment may be carried en route to the country and as railroad baggage, in a canvas duffle sack provided with a lock.

Another important item for travel in primitive regions is a folding cot. The ordinary army cot is good. With this, one can have for greater comfort a pad mattress which can be rolled into a bundle. In many places where one is forced to stop, no beds are provided, and in some of the small country inns one would much prefer one's own bed and can set it up independently. In the warm lowlands a hammock takes the place of the cot. In mountain regions where the houses are of adobe, there may be no places from which a hammock can be supported. However, the cot is serviceable in the lowlands. In mosquito-infested regions one should carry a suitable net. Cots may be provided with frames for supporting a net.

In traveling with pack animals, attention should be given to the containers of the baggage. While trunks and boxes can be carried on mules, they are a great nuisance, and sacks are much to be preferred. The author has found the navy duffle sacks of heavy duck to be satisfactory for pack baggage. The cot and mattress fit into one sack. In cool regions one or two blankets should be carried. It is a good plan to use smaller bags for various articles, clothing in one, medicines in another, toilet articles in a third. The articles are thus kept apart, can be more easily found, and pack easily.

While traveling by horse or mule, the author wears heavy army shoes, leather puttees, riding breeches, army wool shirt (khaki in warm countries) and a broad-brimmed cowboy hat. In cold regions such as the páramos of the Andes, he has found a wool-lined leather vest very serviceable. In these regions gloves add to one's comfort.

While traveling with pack train the conditions are primitive and hardships are encountered. It is essential that one make himself as comfortable as possible, especially at night. In addition to the equipment mentioned, a supply of emergency food should be carried as one can by no means depend on finding sufficient food in all places.

In the remarks made above, no reference has been made to travel by pack train or canoe in uninhabited regions. Such travel requires a more elaborate equipment than that outlined in the preceding paragraphs. A botanist traveling independently will not undertake exploration work requiring the outfitting necessary for a party.

Some travelers advise carrying firearms but the author has never found this necessary or advisable. Throughout the civilized regions the natives are, in the main, well disposed if they are treated properly. It might not be amiss to state that travelers in any country will do well to refrain from coming into intimate contact with the women of that country. Jealousy will turn a well disposed husband or lover into a dangerous enemy.

It is important that a traveler should keep in good health during a trip to a foreign country. This is especially true when one is away from the larger cities, in regions where the services of capable physicians are not available. One should be vaccinated against smallpox, and it is desirable to be vaccinated against typhoid. The chief classes of disease to guard against in the tropics are the dysentery group and the malaria group. Since the germs of dysentery enter the system through the mouth, one should avoid drinking unboiled water or milk and eating uncooked vegetables. Theoretically, malaria is prevented by avoiding the bites of infected mosquitoes; in practice, it is difficult to do this completely. Malaria mosquitoes are active at night, and, in the main, suspend operations by day. However, in the feeble light of native huts or roadside inns, one runs a risk of being bitten even in the daytime. In malarial regions one should always sleep under a good net and care should be taken that the space under the net is free from mosquitoes. By malarial regions is meant the lowlands up to about 3000 feet. However, the mosquitoes (of the genus *Anopheles*) may sometimes be found at still higher altitudes. If one is in a region where malaria is known to be prevalent, one should take especial care. From the practical standpoint, the critical hours are between dark and the time when one retires inside his net. The mosquitoes skulk underneath the tables and chairs and attack the wrists, or the legs above the shoes. If the malaria in a district is of a malignant type, one does well to go under the net before dark and remain till sunrise.

One should carry a small supply of simple remedies. It is advisable to consult a reputable physician in one of the large cities in the country where one expects to make excursions. He will be familiar with the common diseases of his locality and can advise as to the remedies to be carried on the trip. In general, one should have something to keep the bowels open. Castor oil is excellent for this but is bulky; cascara pills are convenient. One should also have a remedy

for dysentery. For general purposes, subnitrate of bismuth is good; for amoebic dysentery, it is well to have a few emetin capsules and a hypodermic syringe. Quinine must always be carried in regions subject to malaria. It is important to have tincture of iodine for cuts, abrasions or any kind of skin wound, to prevent infection, which is especially to be guarded against in the tropics. Danger from snake bites is slight; yet in tropical regions it is best to guard against the small risk by having permanganate of potash. In case of a bite, stop circulation with a tourniquet and cut the wound to make it bleed freely; then rub in crystals of permanganate, or, if a hypodermic syringe is at hand, inject a solution around the wound. But for details one should consult a physician before starting on a trip. A little ammonia is convenient for stings of insects. Minor articles that will pay for the trouble of carrying are carbolated vaseline, absorbent cotton and adhesive plaster.

In tropical regions one receives much advice to the effect that whiskey or some form of alcoholic beverage is necessary to keep in good health. The author uses no alcoholic liquors, and has no reason to think that he has suffered any evil consequences from abstemiousness. His experience in tropical regions leads him to believe that alcoholic beverages are more harmful there than in temperate climates and that one does well to restrict their use to a minimum.

It is a great advantage to be able to speak the language of the country fluently, though even a slight speaking knowledge is a help. Of the Latin American countries, French is spoken in Martinique, Guadaloupe, Haiti and French Guiana; Portugese in Brazil; and Spanish in all the others, except the English colonies. If the traveler has no experience in the language of the country he intends to visit, he should acquire such proficiency as is possible in the time at his disposal. A fair reading knowledge is an aid even though one is unable to speak the language. It is important to be able to read notices, time-tables, signs, rules and regulations, and the common things with which one comes in con-

tact frequently. The traveler should carry a pocket dictionary, giving the equivalent words from English to the foreign language, and vice versa. He should especially familiarize himself with the common words, money, numbers, days of the week, toilet room, meals and foods, time, baggage, railroad tickets and so on. Even though a person has a considerable theoretical knowledge of a language, he may be unable to understand the spoken language when he first comes in contact with it. He will have less difficulty with educated people than with the servant or peasant class, the members of which speak a dialect often mixed with Indian words.

When one goes on a trip into remote regions or away from the larger cities, it is advisable to be accompanied by a guide, and if one is not familiar with the language it is well to have also an interpreter. The same person may be both guide and interpreter. One ought not to travel alone unless one is thoroughly familiar with both the language and customs of the country. In selecting a guide, one should consult responsible people to whom one has letters of introduction. It is important that the guide or interpreter should be thoroughly reliable and should have good judgment, for one's success depends upon being able to surmount difficulties and to avoid accidents.

An important part of the equipment of the scientific traveler is his photographic outfit. He wishes to supplement his notes by a photographic record. Since scientists are familiar with cameras and understand taking photographs, only a few points will be mentioned here. The negatives should be developed as soon after exposure as possible. A person may take his own developing outfit or he may utilize the services of local photographers. If the exposed but undeveloped films have to pass through moist warm regions, they will surely deteriorate, the amount of deterioration depending on the time of exposure to unfavorable conditions. Of course, it is not necessary to have prints made.

One may use rolls, film packs or cut films. Glass plates are too heavy to be considered by the traveler. Cut films require a dark room for loading the holders and hence are inconvenient. Film packs are now so satisfactory that they may be recommended for use in a focusing camera. Rolls are used in a kodak or non-focusing camera. Either rolls or film packs should be obtained from the factory enclosed in airtight tin cases. They keep indefinitely until opened.

The best pictures can be made with a focusing camera, with the aid of a tripod. The exact picture can be seen and the time of exposure extended to suit circumstances. If a kodak camera is held in the hands during a snap exposure, the time must not exceed one-fifth of a second, unless the camera is supported against some solid object. A small, light tripod may be used and one may then have full control of time and stop.

For his own work, the present writer gets most satisfactory results by having two cameras. One is a 5 by 7 box with ground glass, with which film packs are used. The bellows may be extended so as to take objects natural size. The extension is used for flowers, fruits and other small objects. This camera is carried in a stout leather case, and the tripod in another. The case must be strong enough to endure the vicissitudes of travel by pack animals.

Several minutes are required to set up this camera and take a picture, but if time is available it is worth while to get the better picture. The writer also carries a kodak, which takes pictures $3\frac{1}{4}$ by $5\frac{1}{2}$ inches on roll films. This is for use when it is inconvenient to set up the large camera. While traveling on horseback, he carries the small camera in the saddlebags for quick use. While traveling by train, he can step out at a station and get a picture when there would not be sufficient time to use the large camera.

It is important to have good lenses and shutters. The record of the negatives should be certain and in sufficient detail to explain fully the scenes taken.

Finally, the traveler is advised to keep a diary in which the incidents of the day are recorded and which may include scientific notes. Some travelers prefer to keep scientific notes and observations in loose-leaf notebooks. These are matters which each person works out for himself.

CHAPTER XVIII

MISCELLANEOUS NOTES

In this chapter have been brought together remarks on subjects not considered in the preceding chapters.

Editorial Hints

It is not intended to go into the details of preparing and editing manuscript, as there are many sources of information available to the student. Among these may be mentioned:

Extract from the style book of the Government Printing Office designed for the use of typewriter operators engaged in preparing manuscript for printing. Compiled by G. McL. Wood, Editor, U. S. Geological Survey, Washington.

Suggestions to authors of papers submitted for publication by the U. S. Geological Survey with directions to typewriter operators by G. McL. Wood, Editor, U. S. Geological Survey, Washington.

Preparation of articles for the Journal of Agricultural Research. Editorial Committee, K. F. Kellerman, Chairman. U. S. Dept. Agr., Washington.

How to prepare a paper for publication. Read at the Marine Biological Laboratory, Wood's Hole, Mass., July 5, 1910, by C. B. Vaux. Williams and Wilkins Company, Baltimore, 1911.

Manual of style. A compilation of typographical rules governing the publications of the University of Chicago, with specimens of types used at the University Press.

The mechanics of writing. A compendium of rules regarding manuscript arrangement, spelling, the compounding of words, abbreviations, the representation of numbers, syl-

labication, the use of capitals, the use of italics, punctuation and paragraphing. By Edwin C. Woolley. Heath & Co.

How to write clearly. Rules and exercises on English composition. By Rev. Edwin A. Abbott. London. Little, Brown & Co.

The manuscript. A guide for its preparation. John Wiley and Sons, Inc., 1924.

Preparation of scientific and technical papers. By Trelease and Yule. Williams and Wilkins Company, Baltimore, 1925.

The student's attention should be directed particularly to the necessity of going over his completed manuscript as critically as if he were editing the work for another. If this is done on the manuscript, the changes in the proof will be limited to typographical errors. If considerable time elapses between the submission of the paper for publication and the actual printing, there may be additional matter to be inserted; but changes in the proof should be reduced to a minimum.

In papers involving the citation of specimens or of bibliography, it is advisable to verify in the galley proof the numbers of the cited specimens and the volume and page numbers of bibliographic citations.

Illustrations

The illustrations commonly used for scientific papers are half tones from photographs or zinc etchings from line drawings. Half tones cost approximately three times as much as line drawings for the cuts. The cost of preparing copy for the cuts in the two cases depends upon the skilled labor that goes into each. If photographs are prepared by the author, the cost is slight. If the services of an artist are required for the drawings, the cost may be considerable. Some authors are sufficiently skilful to prepare all their drawings themselves, but many can not do creditable work on such subjects as the habit sketches of plants. Almost any

scientist can, with a little practice, prepare diagrams and detail drawings that do not require much perspective. The young author is strongly advised to prepare his own drawings of details and of flat objects. Painstaking work only and not artistic ability is required to do this. Helpful suggestions on amateur illustrating have been published by Mrs. Chase.[1] Any least artistic ability one may have can be utilized in making habit drawings or illustrating objects demanding perspective. Making sketches from nature, in the field book, develops such ability.

Drawings should be at least twice the size of the picture as it is to appear, so that in reproduction the inequalities of lines may be smoothed out.[2] Lines should not be too close together, or in reduction they may coalesce and become smudgy. The drawings are first made in outline with a hard pencil and then inked in with India ink and a fine pen. In drawing details under a dissecting microscope, the object may be placed on a glass stage ruled in millimeter squares. The drawing is made on paper ruled in squares according to the magnification desired, centimeter squares for a magnification of 10 diameters. A proportional divider is very useful, especially when the object is not placed on a ruled stage.

Shading, if one can manage it skilfully, adds greatly to the effectiveness of drawings. A study of good illustrations, together with close observation of the shadows in the object, will help one to use shading effectively.

Flowers, spikelets and similar objects from dried specimens are soaked in water before being dissected. Boiling expedites the process. When soft, the object is removed from the water and placed on the slide, the excess moisture being removed with a blotter. A little glycerine added to the water prevents the object from drying out during the dissection.

Maps showing geographic range are useful and can be pre-

[1] Rhodora **13** : 93. 1911.

[2] Barnes, Bot. Gaz. **43** : 59. Illustrating Botanical Papers.

pared in a simple manner by placing dots upon an outline base map. One prepares first a line drawing (easily made by tracing) of the region to be included, the United States for example. A cut is made from this and a number of maps are printed. The range, as shown by specimens or selected localities, is then indicated on the map by dots or other distinctive markings. If dots are used they may be conveniently placed on the map by a slender piece of wood tapered to a smooth circular end and dipped in India ink.

Indexing[1]

When one has labored to prepare a flora, a revision of a genus or family, or any other botanical work, it is necessary that it be adequately indexed if the results of this labor are to be rendered readily available.

The index is prepared from the page proofs after all changes, which might involve the shifting of one or more lines from one page to another, have been made. All botanical and vernacular names, wherever they occur in the text, should be indexed. Any information that one would not naturally look for under a botanical name, such as poisonous plants, geological formations, soils, life-zones, morphological or physiological discussions, should also be indexed. In indexing subjects, a leading word that one would reasonably look for should be chosen. Suppose, for example, there is a discussion of "The effect of forest and prairie fires on plant succession." One seeking this information would not look for "effect" but most probably for "fire," possibly for "forest," "prairie" or "succession." The slips for this subject would therefore be written:

Fires, forest, effect of, on plant succession..... 67
Fires, prairie, effect of, on plant succession..... 71
Forest fires, effect of, on plant succession..... 67
Prairie fires, effect of, on plant succession..... 71
Succession, plant, effect of forest fires on..... 67
Succession, plant, effect of prairie fires on..... 71

[1] Contributed by Mrs. Agnes Chase.

To make a good subject index demands care and judgment. Each page is carefully scanned, and every name (or subject), with the page number, is written on a separate slip. Cheap small pads of scratch paper (or the backs of old plant labels) are convenient.

In almost any work, the same name is likely to appear on different pages. It saves time to write a second and a third slip, rather than seek the first one. The user of the index will be grateful if the principal reference is distinguished by bold-face or italic type. In writing the slips, these principal entries may be underscored or encircled. Synonyms are usually printed in italics; such names should be underscored on the slips. Since an index must be accurate, it is well to note the page number as each slip is finished. After writing several slips for page 132, say, one's hand may repeat that figure involuntarily. It is necessary to keep close watch to prevent errors.

To guard against loss, the slips should be placed in a box or other receptacle as written.

When slips for the entire work have been written, there comes the work of sorting. If the index is a large one, it simplifies the task to sort first into two lots, *A* to *L* and *M* to *Z*. This can be done very rapidly since only the initial letter of the leading word is noted. The two lots are then again divided, *A* to *F*, *G* to *L*, *M* to *R*, and *S* to *Z*. These four lots, of only six to eight letters each, can now be sorted into the initial letters with a rapidity and accuracy impossible in handling twenty-six letters. As the lots are completed, the slips for each letter are fastened with a rubber band and set aside in order. When the twenty-six lots are ready, each lot is sorted on the leading word in *strict* alphabetical order, the large lots being again divided and subdivided to facilitate sorting. If one can readily use the alphabet backwards, it is more convenient to begin at *Z*, because the slips can then be kept face up. As the slips are sorted some names will appear on several. The page numbers may be copied on to one slip, and the others, after one has noted that the pages have

been accurately transferred, may be discarded. Every detail in an index demands watchfulness, for an index must, above all, be accurate.

When all the slips have been arranged in alphabetical order, they are quickly made into convenient copy as follows: With a quantity of scratch paper before one, a broad strip of paste is laid on the sheet from top to bottom. Beginning with *A*, the slips are set in order on the strip of paste until the sheet is full. This process is repeated with another sheet until all the slips have been pasted.

At this point the index should be examined very carefully to see that all entries are in strict alphabetical order, and corrections made where necessary. Then it should be read with care to see that names are correctly spelled, that a species has not somehow managed to slip into a genus not its own, that references to subjects are worded in the most helpful way, that the synonyms and the principal references are indicated. The slightest doubt should be settled by reference to the page proofs; one should *never* take chances in an index, no matter how wearisome the task has become. The author of any work has a thousand details in mind which will enable him to catch an error that would not be apparent to anyone else. That is one reason why the author should himself make his index, or at least should examine it most thoroughly at this stage.

Before the index is typed for the printer, the author must decide in what form it is to appear. This is usually uniform for a series published by any institution, or by any publishing house. If the work in question is to be one of a series, the index of another book of the same series is examined and the style of that followed. If it is not one of a series, the author should examine recent works that are well-indexed, choose a style, and then adhere strictly to it. The most convenient style for the user is as follows:

*

This, however, takes a good deal of space. All entries under a single word may be run in, thus:

Blue bunch-grass 4, **31,** 88.
Blue bunch wheat-grass, 88.
Bluegrass 4, **38,** 41; annual, 44; Canada, 44; English, 33; Kentucky, **41,** 44; little, 45; malpais, 45; Texas, 44.
Bluejoint, **121,** 122.
Bluestem, 87; big, **263,** 264; little, 260, **261.**
Blumenbachia, 266.
Bottle-brush grass, **98,** 99.
Bouteloua, 4, **191,** 193; americana, 191; aristidoides, **193,** 194; *oligostachya*, 193; procumbens, 193, **194.**

In some indexes, especially in older books, generic names only are indexed. Such an index is a constant source of irritation to the user. An index is meant to lead to information without loss of time. A partial index saves but a small fraction of the time an index should save. This is especially true in a work where synonyms are cited. The author may

save himself a few hours of work by reducing his index to generic names, but each user of the book is obliged to spend at least as much time as the author saved — and the author is one, the users are many. In some works there are two indexes, one to Latin, the other to English names. (In Linnaeus' "Species Plantarum" there are three, Index generum, Index synonymorum, and the index to Nomina trivialia.) Time is saved in using a book if all entries are placed, in strict alphabetical order, in a single index.

When all corrections have been made in the copy, the index should be typed in the form chosen. The typed copy must be carefully compared with the original copy and the type marked, underscore for italics, a wavy line for bold-face type. The last work on the index is to read the proofs with the greatest care, again referring to the page proofs to settle the slightest doubt.

Choice of Names for Genera and Species

It is well to choose names that are short and that express some character of the plant or associate the plant with a person or place. Names derived from two languages should be avoided. It is well also to avoid names difficult to Latinize or to pronounce, such as those derived from the long names of places in primitive countries; to avoid names derived from little-known places, such as *yadkinense* (from the Yadkin River); to avoid names derived from those of persons having nothing to do with the plant; to avoid compound personal names such as *Charles-Smithia* and *Adelmeria* (A. D. Elmer); to avoid such prefixes as pseudo, used merely to connect a new name with an old one.

The following case illustrates what may come from the use of personal names. Caralluma Nebrownii Dint. & Berg. was named for N. E. Brown. A closely allied species was named C. pseudo-Nebrownii Dinter. The latter species was illustrated in plate 8982 of Curtis' Botanical Magazine, but the name was altered to C. pseudo-N. E. Brownii. In the text for this plate Stapf says, "I have attempted to assure the correct pronuncia-

tion of the compound usually spelled "Nebrownii," namely, N. E. Brownii, by treating the first two letters as initials, the species being dedicated to Mr. N. E. Brown, and not to a man of the name Nebrown. It would be altogether better to avoid combinations of that kind."

In general, personal names and place names should be used sparingly. The lavish use of such names usually indicates indolence on the part of the author of the species. If a little patience is exercised, a Latin or Greek dictionary will usually yield a suitable name.

An Author's Duty in Coördinating Publication and Herbarium

When an author has published a taxonomic article, he should leave a record in the herbarium that corresponds with the publication. The types of the new species should be plainly marked. The material studied should be named in accord with the published work. Endless confusion has been caused by a failure to do these things. One may intend to name a species *alba* and so label the specimens; later, for some reason one may decide to name it *candida*, publish the latter name, but leave the name *alba* written upon the sheets, to the confusion of later workers. One should keep in mind the general principle that any published work is for the use of others and should make it as useful to others as possible.

Hackel published *Themeda gigantea* subsp. *intermedia*, var. *dubia* Hack., Insulae Philippinae (Cuming 1609). This plant in the Vienna Herbarium is named, in Hackel's script, *Themeda gigantea* var. *villosa* Hack. He published another variety as *Themeda gigantea* subsp. *intermedia* var. *intermedia* Hack., Mount Khasia (Hook. f. Thoms. sub Andropogon nr. 4); but the specimen in the Vienna Herbarium is named, in Hackel's script, *Anthistiria gigantea* γ *dubia* Hack. If one depended only upon the names on the sheets, one would be misled.

Location of Some Type Specimens of American Grasses[1]

The following notes refer to grasses, but in most cases the location of the types of grasses indicates in a general way the location of the types of other families. For convenience they are arranged according to cities.

London. The Linnaean Herbarium is at the rooms of the Linnaean Society. The Herbarium at the Royal Botanical Gardens at Kew is one of the largest in the world. The collections there have been enumerated from time to time in the *Bulletin of Miscellaneous Information.* At the British Museum of Natural History, South Kensington, are many important early collections. The only known herbarium of Walter, though fragmentary, includes many types of the species described in the " Flora Caroliniana." A collection by Hans Sloane supports his " History of Jamaica."

Paris. The herbarium of the Muséum d'Histoire Naturelle, Jardin des Plantes, probably as large as the Kew Herbarium, is of great interest to American botanists. Here is the Michaux Herbarium, many of the types of Fournier (Mex. Pl.), Steudel (Syn. Pl. Glum.), Lamarck, Poiret, Humboldt, Bonpland and Kunth, and others. Within recent years this herbarium has absorbed the herbaria of Drake de Castillo and of Cosson.

Berlin. The herbarium is at the Botanical Garden at Dahlem. From the historic standpoint, the most important collection is the Willdenow Herbarium, which is kept apart. The general herbarium contains Kunth's herbarium, with many "H.B.K." types, Nees' herbarium with many of his types, and the South American collections of Pilger, Fiebrig, Ule, Weberbauer and others. The Krug and Urban herbarium, the fullest representation of West Indian flora and the basis of Urban's " Symbolae Antillanae," is kept apart.

[1] See also notes on American and European Herbaria examined. North American Species of *Panicum.* (Contr. U. S. Nat. Herb. **15** : 1–4. 1910.)

Geneva. The Delessert Herbarium (Conservatoire et Jardin Botanique) contains a large number of types. The early collections are enumerated in Lasegue's work. The De Candolle Herbarium, containing the types of the " Prodromus," has been recently acquired. The Boissier Herbarium is now at the University (Institut de Botanique de l'Université — distinct from the Herbier Delessert).

Vienna. The herbarium at the Natural History Museum is rich in the collections of D'Orbigny, Mandon, Lechler, Reichenbach, Philippi, and many others. It contains also the important Hackel Herbarium of grasses.

Stockholm. An important collection here is the Swartz Herbarium of Jamaican plants. There are also the collections from South America of Regnall, Widgren, Malme, Lindman, Ekman, and Fries.

Leningrad. To the agrostologist the most important collection here is the Trinius Herbarium at the Academy of Sciences. The herbarium of the Botanical Garden is well supplied with earlier collections.

APPENDIX

RULES FOR ABBREVIATING BOTANICAL TITLES AND THE NAMES OF AUTHORS

The following rules and principles governing the abbreviation of botanical titles and the names of authors are used in preparing manuscript for the Contributions from the National Herbarium.

The following (paragraphs numbered 1 to 5) are taken from the "Rules for the abbreviation of titles of scientific periodicals in publications of the Smithsonian Institution and its branches."

1. In abbreviating words in titles, stop before the 2d vowel, unless the resulting abbreviation would contain but one consonant, in which case stop before the 3d vowel.

Examples:

Abhandlung = Abh.
Academy = Acad.
Bericht = Ber.

Explanations and Exceptions

A. The following words have irregular abbreviations to avoid confusion with other words having the same beginning, but different termination, or for other reasons:

Analytical = Analyt.
Architecture (or -al) = Archit.
Astrophysics (or -ical) = Astrophys.
Bibliography (or -ical) = Bibliogr.
College (not abbreviated).
Columbian = Columb.
Ethnography (or -ical) = Ethnogr.
Experimental = Exper.
Herausgegeben = Hrsg.
Industrial = Indust.

Manufactures (or -ing)	= Mfr.
Mining	= Mg.
Monthly	= Mo.
Monograph	= Monogr.
Philosophy (or -ical)	= Philos.
Physiology (or -ical)	= Physiol.
Public (or publication)	= Pub.
Repertorium	= Repert.
Repository	= Repos.
Science (or scientific)	= Sci.
Sociology	= Sociol.
Statistics (or -ical)	= Statist.
Telephone (or -ic)	= Teleph.

B. The following abbreviations in common use, also the ordinary post-office abbreviations for States of the United States, are allowable: R. R. (railroad); C. R. (comptes rendus); k. k. (kaiserlich und königlich), U. S. (United States); N. S. W. (New South Wales); Lond. (London); Par. (Paris); Ber. (Berlin); St. Petersb. (St. Petersburg); Phila. (Philadelphia), etc.

C. Compound German, Norwegian and Swedish words may be abbreviated (*a*) by adding to the first component the consonant or consonants immediately following, or (*b*) by abbreviating each component according to rule 1 and connecting them by hyphens.

Examples:

Monatsbericht	= Monatsb. or Mon.-Ber.
Naturvidenskabeligt	= Naturv. or Nat.-Vid.
Landhushållning	= Landh. or Land-Hush.

D. Numerals occurring in titles should be treated thus:

Fiftieth	= 50th.
Fifteenth	= 15th.
Deuxième	= 2me.
Vierte	= 4te, etc.

2. All articles, prepositions and conjunctions are to be omitted, except *and* and *for*, which may be retained when necessary for clearness.

Examples:

Bollettino dei Musei di Zoölogia ed Anatomia Comparata. — Boll. Mus. Zoöl. ed. Anat. Comp.

Proceedings of the Academy of Natural Sciences of Philadelphia. — Proc. Acad. Nat. Sci. Phila.

Mémoires pour servir à l'Histoire Physique et Naturelle de la Suisse. — Mém. Hist. Phys. et Nat. Suisse.

3. In abbreviated titles, the words should follow strictly the order of the full titles.

Examples:

Proceedings of the Biological Society of Washington. Proc. Biol. Soc. Washington; *Not* Washington Biol. Soc. Proc.

Annales de la Société Entomologique de Paris. — Ann. Soc. Ent. Paris; *Not* Paris Ann. Soc. Ent.

4. (*a*) Words of one syllable, (*b*) titles consisting of a single word, (*c*) names of towns (except as indicated under rule *B*), (*d*) names of persons (when unmodified), and (*e*) names of geological formations, are not to be abbreviated.

5. Whenever necessary for clearness, any of the foregoing rules may be disregarded, but in such cases words should not be abbreviated.

GENERAL PRINCIPLES TO BE OBSERVED IN ABBREVIATING BOTANICAL TITLES OR THE NAMES OF AUTHORS. THESE ARE IN ADDITION TO THE RULES QUOTED ABOVE

Abbreviations of Titles

1. Abbreviations to be chosen from the title, and to be in the order in which the words occur in the title.

Civ. Nat. Hist. Jam. The civil and natural history of Jamaica.

2. Additional words not in title are to be placed in parenthesis.

Denkschr. Akad. Wiss. Math.-Naturw. (Wien). Denkschriften der kaiserlichen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse. Wien.

3. In abbreviating words in titles other than those of periodicals, rule 1 of Smithsonian Rules is usually followed, but to avoid ambiguity, the abbreviation may extend to the vowel of the 3d syllable.

Monogr.

4. Many common words are specially abbreviated.

Pl. = Plant. N. S. E. W. = North, etc.
Fl. = Flora. Dept. = Department.
Sp. = Species.

5. Diacritical marks are to be preserved when they occur in the part of the word retained in the abbreviation.

Mém. = Mémoire. Rév. = Révue.
Franç. = Française. Zuñi

6. The word " and " or " et " (Latin), when retained, is represented by the sign &, in titles or joining the names of authors. The " *and* " may be retained or not when it occurs between retained words.

Nov. Gen. & Sp. Bot. S. C. & Ga. [and]
Fl. Peru. Chil. [et].

7. Words may be abbreviated before the last vowel, though it saves no space.

Graec. (Graeca), Neu. (Neue).

8. The abbreviations of titles of periodicals must be full enough to distinguish between different series.

Ann. Sci. Nat. II. Bot. to distinguish from other series.
Journ. Linn. Soc. Bot.
Trans. Linn. Soc. Bot.

9. Certain words are not abbreviated.

Grasses, Club.

10. Certain abbreviations have been approved as follows:

Agrost., Encycl., Icon., Monogr., Phytogr., Pugill.

11. In choosing words for abbreviation, especially in long titles, it is well to retain (*a*) the first significant word,

(*b*) words which indicate the systematic group treated, or the geographical area concerned.

12. The abbreviations of Government publications should include U. S.

U. S. Dept. Agr. Div. Agrost. Bull.
U. S. Rep. Expl. Miss. Pacif.
Contr. U. S. Nat. Herb.
Proc. U. S. Nat. Mus.

13. The names of editors may be placed in the possessive when this has been sanctioned by long usage.

Curtis's Bot. Mag.
Edwards's Bot. Reg.
Rees's Cycl.

14. Such abbreviations as Trans., Bull.. Rep., may be placed out of their sequence in the title.

Rep. Mo. Bot. Gard. (Mo. Bot. Gard. Ann. Rep.).

15. Bulletins of State Agr. Exp. Sta. to be similar to this:

N. C. Agr. Exp. Sta. Bull., *not* Bull. N. C. Agr. Exp. Sta.

Abbreviations of Names of Authors

1. Words of one syllable are not abbreviated.

2. Words of more than one syllable, when abbreviated, should go to the vowel of the second syllable.

3. The following names of authors are specially abbreviated: Linnaeus (L.), A. P. De Candolle (DC.), Britton, Sterns & Poggenberg (B.S.P.), Humboldt, Bonpland & Kunth (H.B.K.), Michaux (Michx.), Robert Brown (R. Br.).

4. To distinguish different authors of the same name, initials may be used; or in case of father and son, the name of the latter, or its abbreviation, may be followed by f. (filius).

5. Names that, to avoid confusion, are not abbreviated when standing alone, may be abbreviated when combined with another. Britton, Britt. & Rose.

MISCELLANEOUS EXAMPLES OF BIBLIOGRAPHIC CITATIONS

Method of citing volume, page and year:

12 : 224. 1909.
12 : 224, 225. 1909.
12 : 224–237. 1909.
12 : 224. *pl. 3.* 1909.
12 : 224. *pl. 3. f. 1.* 1909.
Mart. Fl. Bras. **2**^{2}: 188. 1877.
Doell in Mart. Fl. Bras. etc., when Doell is the responsible author.
Hochst.; Steud. Syn. Pl. Glum. etc., when Steudel adopts Hochstetter's name without description.

Method of citing synonymy:

Names cited as originally published: Examples, *Panicum dichotomum* β *glabrescens* Griseb.; *Panicum*, section *Lasiacis* Griseb.; *Cenchrus echinatus* var. *viridis* Spreng.
Doubtful synonyms indicated thus, *? Panicum durum* Desv.
Name mentioned in synonymy, *Andropogon domingensis* Spreng.; Steud. Nom. Bot. ed. 2. **1** : 91. 1840, as synonym of *A. stipoides*.
Homonyms,
Panicum gracilicaule Nash in Small, Fl. Southeast. U. S. 98. 1903. Not *P. gracilicaule* Rendle, 1899.
Agrostis pyramidalis Lam. Tabl. Encycl. **1** : 161. 1791. Not *Sporobolus pyramidalis* Beauv. 1807.

New genera and species:

Triniochloa Hitchc., gen. nov.
Triniochloa laxa Hitchc., sp. nov.

Type-basis Code of Botanical Nomenclature

At the Baltimore meeting of the Botanical Society of America (1918), the Committee on Generic Types presented a set of rules for fixing the types of genera. The report was published in SCIENCE (**49**: 333–336. 1919). At the same meeting the committee was enlarged to nine mem-

bers and made a standing committee on botanical nomenclature, with authority to prepare a code of nomenclature. The standing committee consists of LeRoy Abrams, N. L. Britton, E. A. Burt, A. W. Evans, J. M. Greenman, A. S. Hitchcock (chairman), M. A. Howe, F. W. Pennell and C. L. Shear.

The following code was presented by the committee but was not acted upon by the society.

PRINCIPLES

1. The primary object of formal nomenclature in systematic biology is to secure stability, uniformity, and convenience in the designation of plants and animals.

2. Botanical nomenclature is treated as beginning with the general application of binomial names to plants (Linnaeus' "Species Plantarum," 1753).

3. Priority of publication is a fundamental principle of botanical nomenclature. Two groups of the same category can not bear the same name.

Note a. This principle applies primarily to genera and species.

Note b. Previous use of a name in zoölogy does not preclude its use in botany; but the proposal of such a name should be avoided.

4. The application of names is determined by means of nomenclatural types.

Note. A generic name is always so applied as to include its type species; a specific name is always so applied as to include its type specimen.

RULES

Section 1. Publication of Names

Article 1. A specific name is published when it has been printed and distributed with a description, or with a reference to a previously published description.

Note. A recognizable figure may be the equivalent of a description in the literature of paleobotany and diatoms.

(*a*) In the transfer of a species from one genus to another, the original specific name is retained, unless the resulting binomial has been previously published.

Recommendations: Botanists will do well, in publishing:

1. In describing parasitic fungi to indicate the host and to designate the name of the host by its scientific Latin name.

2. To give the etymology of all new generic names.

Article 2. A generic name is published when it has been printed and distributed

(*a*) With a generic or specific description (or a recognizable figure, see Art. 1, note) and a binomial specific name,

(*b*) With a generic and specific name and the citation of a previously published description,

(*c*) With a definite reference to at least one previously published binomial.

Note a. A name is not published by its citation in synonymy, nor by incidental mention. Such a name may be taken up but not to replace one already properly published.

Note b. Of names published in the same work and at the same time, those having precedence of position are to be regarded as having priority.

Recommendation: Botanists will do well, in publishing, to give the etymology of specific names when their meaning is not obvious.

Section 2. Application of Names

Article 3. The nomenclatural type of a species is the specimen or the most important of the specimens upon which its original published description was based.

(*a*) If only one specimen is cited, that is the type.

(*b*) If one specimen is designated as the type, that specimen shall be so accepted, unless an error can be demonstrated.

(*c*) A species transferred without change of name from one genus to another retains the original type even though the description under the new genus was drawn from a different species.

(*d*) The publication of a new specific name as an avowed substitute for an earlier one does not change the type of the species.

(*e*) When more than one specimen was originally cited and no type was designated, the type should be selected in accordance with the following:

1. The type specimen interprets the description and fixes the application of the name, hence, primarily the description controls the selection of the type.
2. The type may be indicated by the specific name, this being sometimes derived from the collector, locality or host.
3. If one specimen is figured in connection with the original description this may usually be regarded as the type.
4. Specimens that are mentioned by the author as being exceptional or unusual, or those which definitely disagree with the description (provided others agree) may usually be excluded from consideration in selecting the type.

5. An examination of the actual sheets of specimens studied by the author may aid in determining or selecting the type. He may have written the name or left notes or drawings upon one of the sheets.

Note. Specimens known to have been received by the author subsequent to the study resulting in the original publication should be excluded from consideration.

6. If an author, in publishing a new species, gives a description of his own, this takes precedence over synonymy or cited descriptions, in determining the type specimen.

Article 4. The nomenclatural type species of a genus is the species or one of the species included when the genus was originally published.

If a genus includes but one species when originally published this species is the type.

When more than one species is included in the original publication of the genus, the type is determined by the following rules:

(*a*) When, in the original publication of a genus, one of the species is definitely designated as type, this species shall be accepted as the type, regardless of other considerations.

If *typicus* or *typus* is used as a new specific name for one of the species, this species shall be accepted as the type as if it were definitely designated.

(*b*) The publication of a new generic name as an avowed substitute for an earlier one does not change the type of the genus.

(*c*) If a genus, without an originally designated type, contains among its original species one with the generic name used as a specific name, either as a valid name or synonym, that species is to be accepted as the type.

Example. The type species of Pentstemon (Ait. Hort. Kew. **2** : 360. 1789) is *Chelone Pentstemon* (L. Sp. Pl. 612. 1753; ed. 2. 850. 1763) because the latter is cited as a synonym under one of the species of *Pentstemon.*

(*d*) If a genus, when originally published, includes more than one species, and no species is definitely designated as type, nor indicated according to (*c*), the choice of the type should accord with the following principles:

1. Species inquirendae or species doubtfully referred to the genus, or mentioned as in any way exceptional are to be excluded from consideration in selecting the type.

2. Genera of the first edition of Linnaeus's "Species Plantarum" (1753) are usually typified through the citations given in the fifth edition of his "Genera Plantarum" (1754) except when inconsistent with the preceding articles.

Example. Arundo (L. Sp. Pl. 81. 1753) is typified by *A. Donax* since

this is the species figured by Scheuchzer in the plate cited by Linnaeus (Gen. Pl. 35. 1754).

3. Species which definitely disagree with the generic description (provided others agree), or which possess characters stated in the generic description as rare or unusual, are to be excluded from consideration in selecting the type.

RECOMMENDATIONS

Article 5. In the future it is recommended that authors of generic names definitely designate the type species; and that in the selection of types of genera previously published, but of which the type would not be indicated by the preceding articles, the following points be taken into consideration:

(*a*) The type species should usually be the species or one of the species which the author had chiefly in mind. This is often indicated by

1. A closer agreement with the generic description.
2. Certain species being figured (in the same work).
3. The specific name, such as *vulgaris, communis, medicinalis* or *officinalis.*

(*b*) The type species should usually be the one best known to the author. It may be assumed that an indigenous species (from the standpoint of the author), or an economic species, or one grown in a botanical garden and examined by the author, would usually represent an author's idea of a genus.

(*c*) In Linnaean genera the type should usually be chosen from those species included in the first technical use of the genus in pre-Linnaean literature.

Example. The type species of *Andropogon* L. should be chosen from the two species included by Linnaeus in the first use of the name (L. Fl. Leyd. 1740).

(*d*) The types of genera adopted through citations of non-binomial literature (with or without change of name) should usually be selected from those of the original species which received names in the first binomial publication.

Example. Cypripedium (L. Sp. Pl. 951) is typified by *C. Calceolus.* Under *Cypripedium* (Gen. Pl. 408. 1754) Linnaeus cites *Calceolus* Tourn. 249. Tournefort mentions 5 species, one of which is cited under *Cypripedium Calceolus* by Linnaeus.

(*e*) The preceding conditions having been met, preference should be shown for a species which will retain the generic name in its most widely used sense, or for one which belongs to a division of the genus containing a larger number of species, or, especially in Linnaean genera, for the historically oldest species.

Example. *Phalaris* L. is typified by *P. canariensis* because it is the only one of the 5 Linnaean species known to the older writers (such as Bauhin) by the name of *Phalaris*, so far as shown by the synonyms given by Linnaeus.

(*f*) Among species equally eligible, the preference should be given to the first known to have been designated as the type.

(*g*) If it is impossible to select a type under the conditions mentioned above the first of equally eligible species should be chosen.

Section 3. Rejection of Names

Article 6. A name is rejected:

(*a*) When preoccupied (homonym).

1. A specific name is a homonym when it has been published for another species under the same generic name.

2. A generic name is a homonym when previously published for another genus.

3. Similar names are to be treated as homonyms only when they are mere variations in the spelling of the same word; or in the case of specific names, when they differ only in adjective or genitive termination.

(*b*) When there is an older valid name based on another member of the same group (metonym).

(*c*) When there is an older valid name based on the same type (typonym).

(*d*) When it has not been effectively published according to the provisions of Section 1 of these rules (hyponym).

Article 7. There may be exceptions to the application of the principles and rules of this code in cases where a rigid application would lead to great confusion. Such exceptions become valid when approved by the Nomenclature Commission.

NOMENCLATURE COMMISSION

A code of nomenclature should secure uniformity, definiteness and stability in the application of names. If proposed rules result in the change of well-established names of economic plants, botanists will hesitate to apply them uniformly. All contingencies can not be foreseen and experience has shown that the rigid application of any set of rules results in a few cases of greatly confused nomenclature. The committee has recognized this and hence has introduced an article permitting exceptions. The committee also recognized that to secure uniformity and definiteness the exceptions should in some way be validated. The most convenient and practical validation would be through a permanent judicial body created for the purpose. As the proposed code invites international

support, the judicial body should be an international commission. International rules of nomenclature, including rules for the retroactive fixation of generic types and including a provision for exceptions, together with an International Commission to validate names (generic types and nomina conservanda) would go far toward giving to botany a stable and uniform nomenclature.

This International Commission should be appointed at the next International Botanical Congress.

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